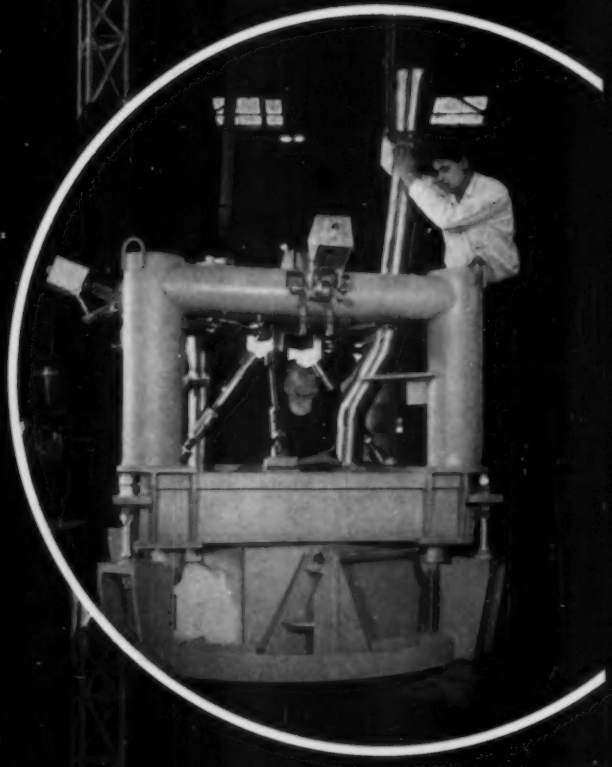
DESIGN
edition

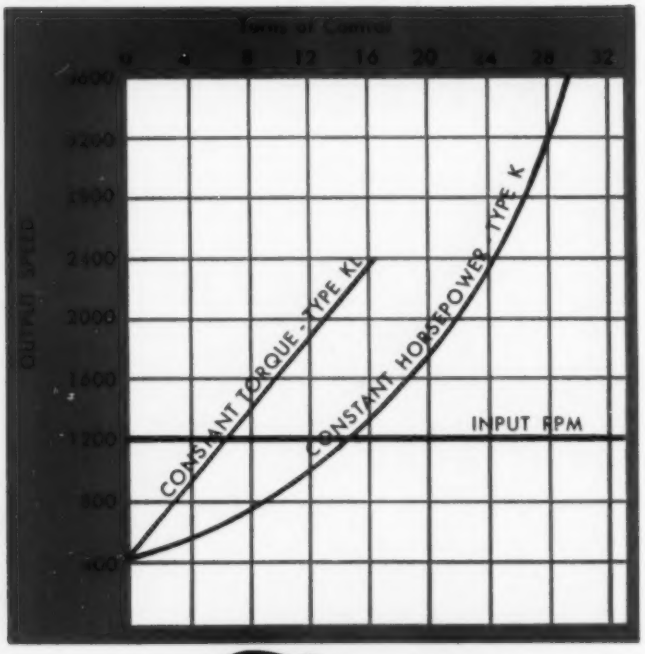
Product Engineering

McGRAW-HILL MAGAZINE OF DESIGN
RESEARCH AND DEVELOPMENT

September 30, 1957
PRICE 50 CENTS

Satellite vehicle will take off (left) from first combined test-launch platform (below) — *page 5*





Typical speed regulation curves for the Types K and KL Variators. Type KL offers a linear speed regulating pattern, often an advantage in automatic control applications. Output speed regulation of the Type K Variator follows a geometric progression pattern. Starting at the minimum output speed, each turn of the speed regulating wheel produces a fixed percentage increase in output shaft speed.

The Cleveland Speed Variator is available in 18 models ranging from fractional to 16 HP at 1750 input RPM. Unit shown at right, used in process control, has speed regulating worm driven by 75 RPM synchronous motor, with adjusting shaft indicating mechanism modified to actuate limit switches to prevent overtravel.

CLEVELAND SPEED VARIATOR

Accurately Provides Dependable, Infinitely Variable Speed Control

ANNOUNCED late in 1954, the new Cleveland Speed Variator met instant, enthusiastic acceptance. Engineers and designers of industrial equipment already have put thousands of units into use on such varied equipment as cigarette making machines, textile machinery, metalworking machinery, pharmaceutical equipment, transfer tables, conveyors and experimental and testing equipment of many types.

Infinitely variable, the Cleveland Speed Variator gives stepless speed over a full 9:1 range—from ⅓ to 3 times input speed. Output speed can be adjusted by either a hand wheel on the Variator or by manual or automatic remote control.

The Cleveland Speed Variator offers these major advantages:

1. An extremely compact unit with input and output shafts in line and rotating in the same direction.

2. Almost any input speed up to 1800 RPM can be used—either clockwise or counterclockwise rotation.

3. Rated for constant horsepower output over a 9:1 or 6:1 range; or for constant output torque over a 6:1 range.

4. Speeds infinitely variable over entire range of adjustment.

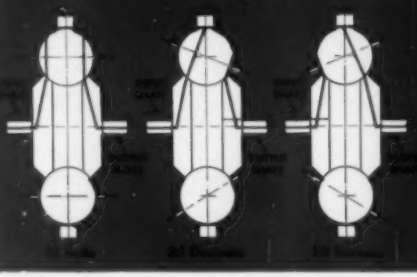
5. No slippage—positive torque response mechanism adjusts in direct proportion to the loads encountered.

6. Long life and minimum maintenance due to absence of belts or complicated linkages.

7. Ample bearing support for overhung pulleys on both input and output shafts.

Write for Bulletin K-200 for detailed description with photographs, sectional drawings, rating tables and specifications.

HOW THE CLEVELAND SPEED VARIATOR WORKS



Power is transmitted from input shaft to output shaft through alloy steel driving balls which are in pressure contact with discs attached to the two shafts.

Relative speeds of the shafts are adjusted by changing the positioning of axles on which the balls rotate (diagram, right, shows cutaway Variator with hand regulating wheel).

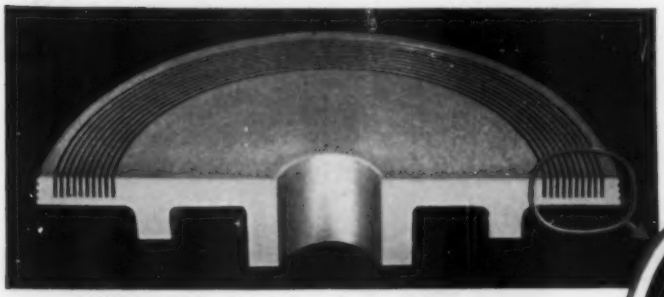
"It's the Drive That's on the Ball."

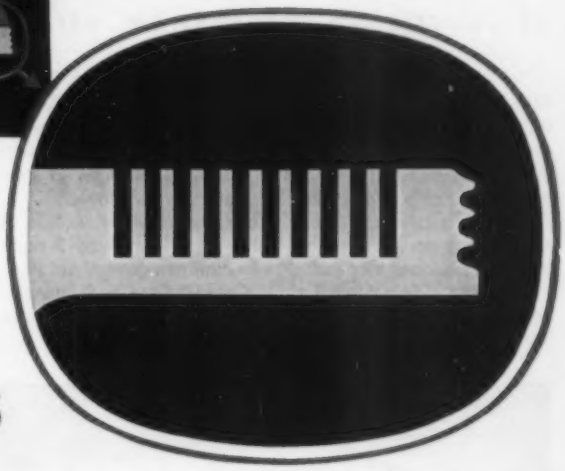
THE CLEVELAND WORM AND GEAR COMPANY

Speed Variator Division, 3279 East 80th Street, Cleveland 4, Ohio

Sales Representatives in all major industrial markets • In Canada: Peacock Brothers Limited.

Do Your Castings Require Sharp Corners *Like These?*





The Denser Structure of EATON PERMANENT MOLD GRAY IRON CASTINGS

Permits the Machining of Precise Corners

The fine dispersion of graphite in Eaton Permanent Mold Iron and its dense, non-porous, homogeneous structure make it an ideal material for many difficult machining operations where accurate dimensional results and sharp corners are essential.

Because its superior structure permits the machining of extremely thin sections and has the ability to take a high surface finish, Eaton Permanent Mold Iron is recommended for such critical applications as bearing retainers, connecting rods, pulleys, carburetor bodies, valve bodies, and service valves.

If you have applications which require these exceptional characteristics, our engineers will be happy to work with you.

The part shown above required that 10 grooves, .023" wide and .125" deep, leaving 9 lands .015" wide, be rapidly and simultaneously machined. Eaton Permanent Mold Iron proved to be the ideal material—completely eliminating the problem of curling chips in the small grooves, and crumbling of lands during machining.

Check these Important Advantages:

- ★ **Dense, non-porous, homogeneous structure**
- ★ **Freedom from inclusions**
- ★ **Excellent tensile strength**
- ★ **Ability to take a high surface finish**
- ★ **Freedom from leakage under pressure**
- ★ **Intricately cored sections**
- ★ **Uniformity of castings**
- ★ **Higher machining feeds and speeds**
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MANUFACTURING COMPANY
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can give your products long life at low cost

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ALUMINIZED STEEL® Type 2, sheet steel coated with aluminum on both sides by a special hot-dip process, gives designers unique opportunities to improve product performance. This economical mill-coated material provides the structural strength of steel and the durable protection of the aluminum coating.

17-year tests in an industrial atmosphere show the life of the coating on ALUMINIZED Steel Type 2 is at least 3 times that of a standard zinc coating on unpainted galvanized steel.

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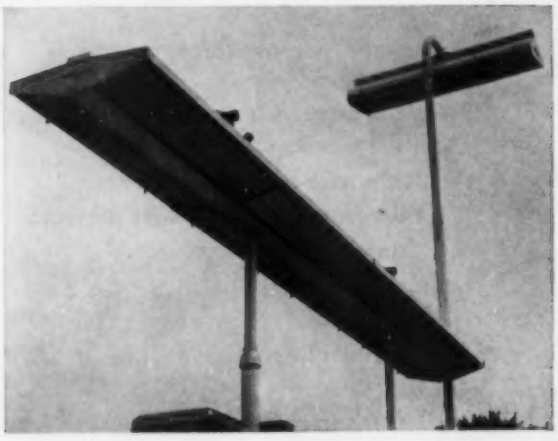

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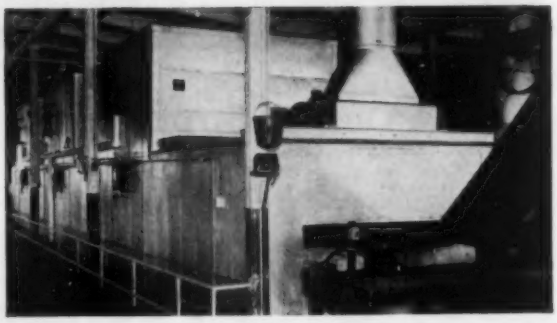
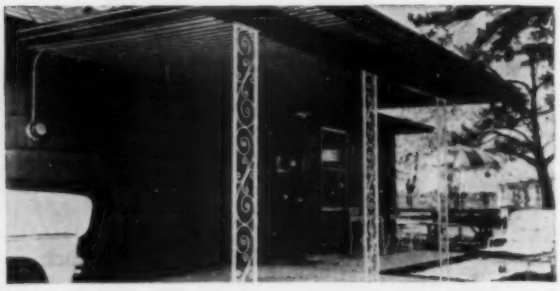


Drying Ovens in Chemical Textile Processing . . . For lasting protection against corrosion without painting, plus savings due to high heat reflectivity of the aluminum coating. (It reflects 80% of incident radiant heat.)



Carports, Awnings, Outdoor Clothes Dryers . . . For most economical combination of necessary strength and atmospheric corrosion resistance.

Armco ALUMINIZED STEEL Type 2 is produced in sheets and coils from 14 to 26 gage. Check the unusual advantages of this metal for *your* products. Let us send you complete information. Just fill in and mail the coupon.

Armco Steel Corporation, 1957 Curtis Street, Middletown, Ohio

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Product Engineering

THE McGRAW-HILL MAGAZINE OF DESIGN ENGINEERING

September 30, 1957 Vol. 28, No. 12

New Low-expansion Ceramics— 70... Herbert Schwartz, Technion Design and Mfg. Co.
Design and applications of a low-expansion material for thermal shock.

Water-lubricated Bearings— 74... Stanley Abramovitz, Continental Bearing Research Corp.
How to adapt design to control corrosion, low viscosity and poor boundary lubrication.

Design of Bolted Assemblies— 79... S. Silwones and A. Degen, Elastic Stop Nut Corp.
Materials recommended for bolts and structures for temperatures up to 1300 F. Test results on high-temperature locknuts.

Design Features in New Products— 84...
Rocket launcher; gas analyzer, solar-controlled camera iris; high-speed dentist drill; ball mill.

Molding Printed Circuits— 90... Norman L. Greenman, Rogers Corp.
Process permits built-in wiring with heavier conductors.

Shortcut for Holding Magnet Design— 94... R. A. Scholten, Indiana Steel Products Co.
Fast, accurate method of determining magnet dimensions for required holding force.

SPECIAL REPORT

Color and Texture in Aluminum—101... R. V. Vanden Berg, Aluminum Company of America.
Surface treatments—mechanical, chemical and electrochemical—plus coloring methods peculiar to aluminum, shown in full color.

Design Digest Issue—109... Complete list of topics included in forthcoming sixth annual edition of this familiar roundup of design data.

Differential Springs Can Stimulate Load—110... George H. Logan, North American Aviation.
Analysis of forces and effect of frictional resistance.

DESIGN ROUNDUP

13 Ways to Couple Fhp Motors—120... Walter Strand, Merkle-Korff Gear Co.
With emphasis on ways to prevent excessive bearing wear.

REFERENCE BOOK SHEET

Torsonial Strength of Shafts—123...
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When you design, you design your products for maximum performance—and **Sealmaster** helps you attain it. **Sealmaster** Ball Bearing Units are engineered and manufactured with the same painstaking quality control you would insist on maintaining within your own plant. **Sealmaster's** exclusive combination of features assure you of maximum performance for each bearing. You'll want full information on how important these features are to you and your own product's performance.

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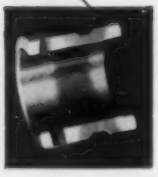
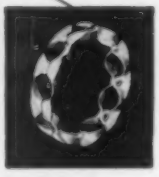
LABYRINTH-SEAL—keeps dust and dirt out and lubricant sealed in for long bearing life.



ZONE HARDENING—assures positive race to shaft holding power.



LANDRIDDEN BALL RETAINER—eliminates ball wear, traps grease and prevents churning.

...For Outstanding Bearing Performance

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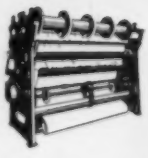
SEALMASTER quality pays off where the trend is to continuous, fast, automatic equipment.



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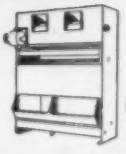
Clean, fast production is assured with SEALMASTER Bearings.

FARM MACHINERY
SEALMASTER Ball Bearing Units keep dust and dirt out, lubricant in...a feature Farm Machinery demands.

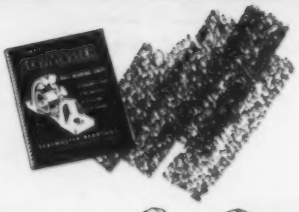
CONVEYORS
SEALMASTER Ball Bearing Units are featured by manufacturers of many types of conveyors.



AIR CONDITIONING
Quiet, trouble-free performance is assured with SEALMASTER. Find out about new rubber mounted units.

CONSTRUCTION MACHINERY
SEALMASTER Ball Bearing Units provide the features for gruelling performance in construction and materials handling equipment.

SEALMASTER® BALL BEARING UNITS



Write for Bulletin 454

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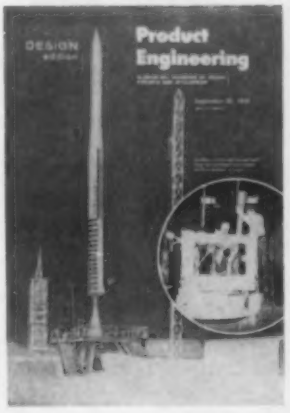
Interesting to Note . . .

The First Satellite



Sometime during the current IGY the US will implant a satellite in outer space. For science-fiction fans, that which has been a fanciful, fictional daydream will soon be a scientific reality. Who first conceived the notion of an earth satellite? The Germans claim the distinction, and naturally the Russians also say they thought of it first. If either country wants the "I thought of it first" title, they would have the difficult job of producing literature that dates beyond 1869. For in that year, the American, Edward Everett Hale (author of *The Man Without a Country*) published a story in *The Atlantic Monthly* that mentions an earth satellite for the first time.

Hale's story, "The Brick Moon," was a narrative describing a 200-ft-dia brick platform orbiting "some 4000 miles above the earth." According to the science fiction authority Sam Moskowitz, "until seven years ago Hale's story was the longest story ever written dealing *only* with the earth satellite theme." Some of the scientific hypotheses supported by Hale may seem näive today. The interior of the moon was braced by "a series of 10 round hollow balls, each held in place by groined arches." The brick moon (built of brick because all known metals of that era would have melted under acceleration) was to be thrown aloft by centrifugal force from "two flywheels built of oak and pine and hooped with iron."

Launching the satellite is still a problem. The expected answer will be the three-stage Vanguard. On our cover is a painting made for the Martin Co. showing a night launching. The closeup is the actual platform designed by Loewy-Hydropress. This firing structure not only launches the rocket, but statically tests and evaluates performance as well. Design consideration of this platform are discussed on page 84.

Crashing The Cost Barrier

When the first aluminum bar was publicly shown at the 1855 Paris Exposition, there was no wild public acclaim. Who could get excited over a dull metal that cost $90 a pound? The material had been known before. Sir Humphry Davy in 1808 announced his

(Continued on page 7)

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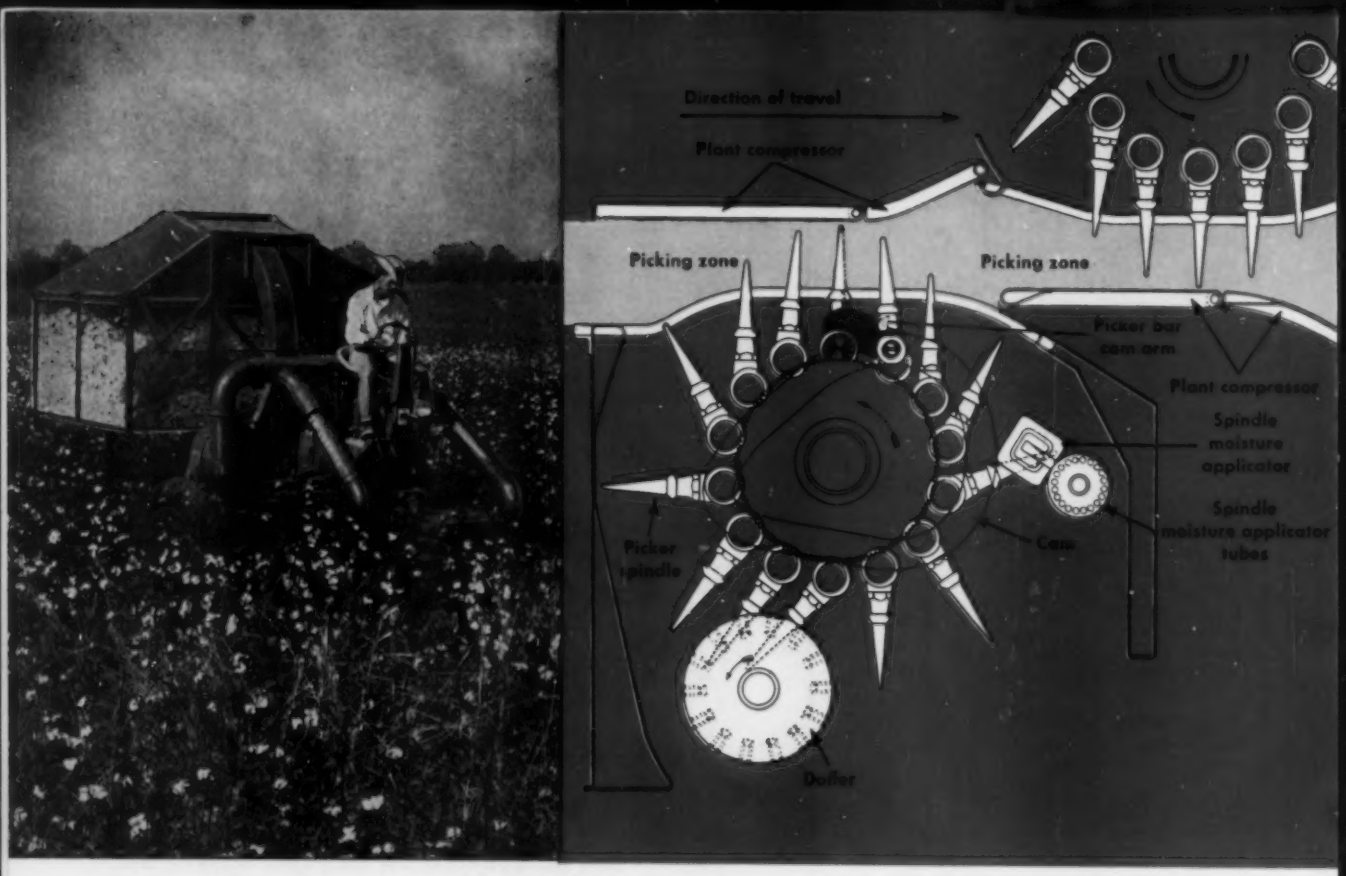

How angular power transmission makes still another improved design practical

This cotton picking machine is just one of many, many products improved and made more practical through the flexibility of angular power transmission.

Using the angle of transmission shown at right, the makers of the machine can put a whole row of spindles on a bar and drive them with a single source. The spindles pluck bolls gently from the cotton plant and deliver them unmarred to a collecting basket.

Besides this flexibility, bevel gear transmissions usually weigh less, cost less, and carry heavier loads.

Our engineers are ready at all times to help you work out applications for bevel and hypoid gears.

They can discuss such items as mountings and lubrication. They can produce and test prototypes of your drives.

Finally, they can advise you on the proper machinery to use to produce top quality gears in large quantities at low costs.

Please write whenever you have an application in mind.

Meanwhile, you'll find these Gleason Technical Handbooks helpful:

20° straight bevel gear system
Spiral bevel gear system
Zerol® bevel system

The cotton picking machine shown above, uses 420 of these tapered spindles in its picking drum (diagram). The machine slashes picking costs by as much as 60%.

GLEASON WORKS

Builders of bevel gear machinery for over 90 years

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Interesting to Note . . .

belief that a plentiful compound, aluminum, was the oxide of an undiscovered metal. Seventeen years later, the Danish physicist-chemist, Hans Christian Oersted, produced a first sample of the metal in his laboratory.

Napoleon III, Emperor of France, saw the bar at the Paris Exposition and realized that his military forces could greatly benefit from lightweight metal armor and artillery. He commissioned the producer of the bar, Sainte-Claire Deville, to bring aluminum costs down to a reasonable level. After years of experimentation, Deville was able to reduce the price to $17 a pound—far too much still for military equipment. Napoleon III continued to be fascinated by the light metal. He had an elaborate set of forks and tablespoons made, and took great pleasure watching the bewildered expressions on the faces of state guests when they discovered its lightness compared to customary, heavy silver or gold table settings.

It was 22-year-old Charles Hall who shattered the high-cost barrier with his electrolytic smelting method in 1886. In 1890 the price was down to $5 a lb; in 1900, $0.33 a lb. Today it is $0.25 a lb and uses run from ax handles to zippers. It appears in all sizes, shapes, forms and textures, and in a rainbow of colors. An article on page 101 discusses the eight basic ways of adding color—several applicable only to aluminum.

Hardware Disease

To keep our large multi-jet bombers flying at top efficiency, over 200 magnets are built into the instruments of a single plane. This is but one of the many uses for the 50 million magnets produced in this country annually. Other uses include door latches, toys, and holders and racks of all types. (A simplified way to design holding magnets is topic of the article on page 94.) One of the strangest uses for a magnet is in preventing "hardware disease."

It seems that when lightning strikes a fence, the charge pops holding staples out of the posts. This in itself does little more than loosen the wire. However, if the wire is fencing in a dairy herd, an additional problem results. Cows aren't fussy eaters. They'll eat anything that gets into their food—dirt, grasshoppers and, unfortunately, wire staples. A farmer reported the death of some fine cattle who ate wire staples from the tall grass growing by his fence posts. Eriez Mfg. Co., Erie, Pa., designed a gadget that could be poked in the grass to pick out undesirable metal, thereby preventing death from "hardware disease."

Then, it was learned that a powder containing iron would not cling to grass seed but did coat the seeds of some weeds. So magnets found another use, separating good seeds from bad.

The Witch Doctor Returns

Sometime this month, a mild, soft-spoken man of 37 will return home and take up his old job. He is an African doctor, Christopher Okojie (pronounced O-KO-GEE), who has just completed a one-year course in general surgery at New York University. His work will be with 195,000 Nigerians, many of them opposed to modern medicine—they still believe in primitive rites and the chants of the local witch doctor. Okojie ought to know—he himself was apprenticed to a medicine man for 2½ years when he was a boy.

A reason for his specializing in surgery, as opposed to general practice, was the fear that native doctors would be hostile to him; they might think he had come, "to take their daily bread from their mouths." Okojie says, "That is why I concentrated on surgery. Because I knew they couldn't do surgery. And it is dramatic. A patient has a big tumor, comes to the hospital where it is removed and within 12 days he's out. This makes an impression. Many of the native doctors have hernias. They come to the hospital secretly, I treat them and we become friends."

His hospital has been shut down for days at a time for lack of water. It has even been surrounded by a singing, jeering mob egged on by local witch doctors. Telephones, cars and ambulances are still objects of the future. Fees? They usually take the form of live chickens and fresh vegetables.

Dr. Okojie does his best with the facilities he has. In the US, a doctor is more fortunate because science is forever finding newer and less painful ways to care for the sick. One new device, in the field of dentistry, is a high-speed drill. The simplicity in design of this "painless" drill is pictured on page 89.

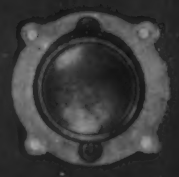
The Amazing Oil Drum

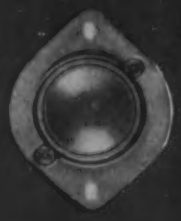
It has been said that Americans are a wasteful lot. This may be true, but as a result of their tossing a steel item onto foreign junk heaps, two local industries have flourished in the West Indies. Old, discarded oil drums, so useful in transporting both crude and refined oil, are now in great demand. It started when a group of Trinidad natives found that music would result if one cut the drums in half and pounded on the steel top with sticks. Hitting the center of the drum produced bass notes while the area near the rim gave higher pitch sounds. So were born the now famous Trinidad Steel Bands that have found their way to our shores on the coattails of the calypso singers.

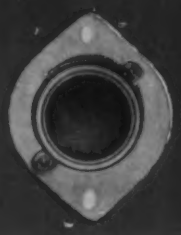
Discarded oil drums are in demand by another group as well. For many years, natives have had to build large wooden rafts to carry the valuable guaiacum trees to market. These trees are too dense to float. Commonly known as lignum vitae, the trees have been a source of laxatives since the 16th Century.

Because of its hardness and density, and the fact that this wood cannot be split, it is widely used in the stern of ships as a tube to contain the propeller shaft. A trickle of sea water constantly lubricates the shaft without rotting the wood. With all the modern improvements in ship construction, the ancient technique of using lignum vitae as a bore is still a common way to water-lubricate the propeller shaft—and also certain types of machine bearings (see article on page 74.) Now, with a few old oil drums strapped to a log, these valuable trees are easily floated to port for world distribution.

—Benedict A. Leerburger, Jr.







CLOSE CONTROL AT A COMPETITIVE PRICE

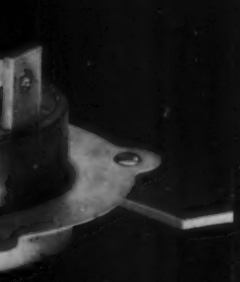
for warm-air
and household heating applications
new **STEMCO**

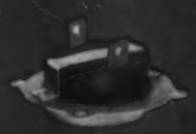
TYPE D THERMOSTATS

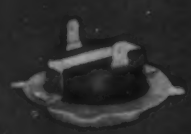
New Stemco Type D Thermostats give laundry dryers, furnaces and warm-air equipment snap-action control—at a competitive price. Two basic styles available: exposed bimetal for rapid response, enclosed bimetal for dust or lint-laden atmospheres. Each is furnished for two or four-hole mounting, either with spade or screw-type terminals. Listed by the Underwriters Laboratories for operation to 300°F.

If your product uses thermostats, check Stemco Thermostats *first*. You'll get *more* thermostat for your dollar . . . *longer* service-free life for your product . . . *more* satisfied customers.

AA-3939







STEMCO Type D thermostats are rated at 25 amps at 120-240 volts ac non-inductive; ½ hp at 120-240 volts ac; 345 voltamps pilot duty.

STEMCO

THERMOSTATS

STEMCO manufacturing company, inc.
Lexington and Mansfield, Ohio

Developments

To Watch

BETTER SHIELDING MATERIALS . . .

. . . for isotope products ("atomic" batteries, thickness gages, liquid level gages), as well as for laboratory use, are on the way. Marblette Corp., for instance, has been working on lead-filled epoxy resins, says it can now produce high-density epoxy casting compounds that contain as much as 95% lead.

While extensive service tests have not yet been made, chances are that lead-filled epoxies would stand up quite well in applications like those noted above. All organic materials are deteriorated by radiation in time; but the thermosetting resins do quite well when only modest amounts of radiation are involved.

ANOTHER EXPLOSIVE THAT MIGHT BE TAMED . . .

. . . for use in powder-actuated devices and metalforming is ammonium nitrate.

Monsanto Chemical Co. says this compound, despite its bad reputation, is actually much safer to handle than most explosives, is easy to control, and costs less than half as much as conventional blasting agents.

Three conditions must be met before the compound will explode. It must be mixed with the correct amount of fuel oil; must be confined; must be detonated. Detonation will likely be one of the bigger problems in adapting ammonium nitrate to product applications (sensitive explosives are the only detonating agents thus far tested). But the idea is worth exploring.

MORE CALCIUM METAL . . .

. . . by two processes now in the development stage could pave the way for new descaling processes, improved steels, new bearing materials (calcium is a hardener for lead), new light-metal alloys, and perhaps even for high-calcium alloys that might in themselves serve as structural materials. One process is being studied in Germany, the other here—by Air Reduction Sales Co.

Calcium is a reactive metal, but not nearly as reactive as sodium. Alloying could increase its strength and give it greater chemical stability. That would make it possible to take advantage of the metal's light weight (about half that of aluminum), electrical conductivity (close to that of aluminum), and high melting point (over 2600 F). It might bring down the price, too. The standard grade now costs $2.40 a lb. in small lots. High-purity (99.9%) metal is about $4.55.

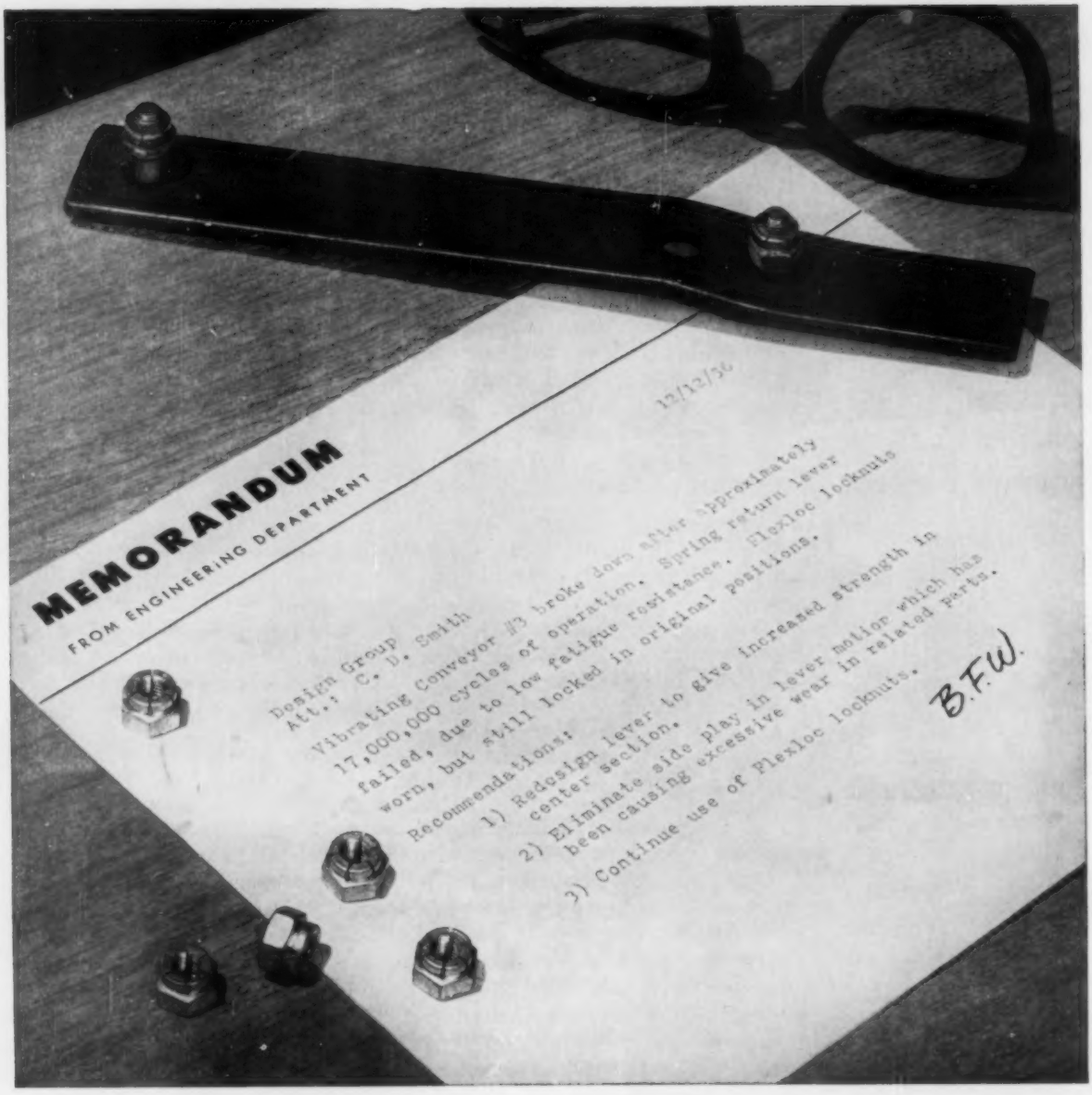
SHOCK RESISTANCE OF A HIGH ORDER . . .

. . . is being specified for many types of equipment as rocket and missile programs go into high gear. And new materials are being pressed into service to meet the demand: foamed silicone resin, for instance.

One new instrument, protected by silicone foam sandwiched between ductile iron housing and stainless steel shell, is said to stand a 400 g shock, and short-term (10 min) exposure to 2000 F. Consolidated Electrodynamics designed it.

LOOK FOR INCREASED ATTENTION TO NOISE . . .

. . . as protests mount against "ordinary" sounds (trucks, riveters, factory and office machines), and as new testing equipment demonstrates the damaging effects of high-powered sound waves. RCA, for example, recently unveiled two "packaged" systems for simulating the effects of in-flight noises up to 145 db. They're said to be the "first units of this type capable of providing complete, flexible fatigue tests of components over a wide frequency range."


MEMORANDUM
FROM ENGINEERING DEPARTMENT
12/12/56
Design Group
Att.: C. D. Smith
Vibrating Conveyor #3 broke down after approximately
17,000,000 cycles of operation. Spring return lever
failed, due to low fatigue resistance. Flexloc locknuts
worn, but still locked in original positions.
Recommendations:
1) Redesign lever to give increased strength in
center section.
2) Eliminate side play in lever motion which has
been causing excessive wear in related parts.
3) Continue use of Flexloc locknuts.
B.F.W.

Why designers specify FLEXLOC self-locking nuts

Where products must be tough . . . must stand up under vibration, shock and abuse . . . designers specify rugged, reliable, precision-built FLEXLOC self-locking nuts as fasteners.

HERE'S WHY:

FLEXLOC locknuts are strong: tensile strengths far exceed accepted standards. They are uniform: carefully manufactured to assure accurate, lasting spring tension in the flexible locking collars. And they are reusable: rough screw threads, repeated removal and replacement, frequent adjustments will not affect their locking life.

Standard FLEXLOC self-locking locknuts are available in a wide range of standard sizes and materials, to meet the most critical locknut requirements. Your authorized industrial distributor stocks them. Write us for complete catalog and technical data. Flexloc Locknut Division, STANDARD PRESSED STEEL Co., Jenkintown 28, Pa.

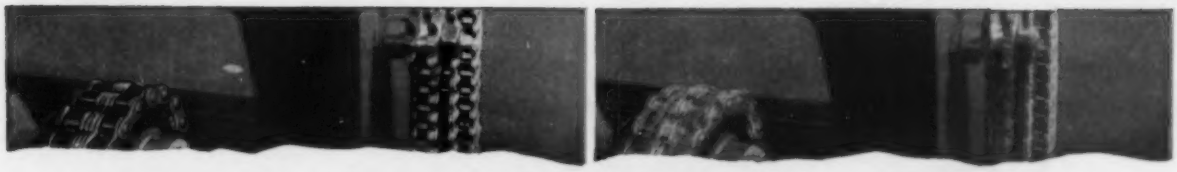
We also manufacture precision titanium fasteners. Write for free booklet.

FLEXLOC LOCKNUT DIVISION

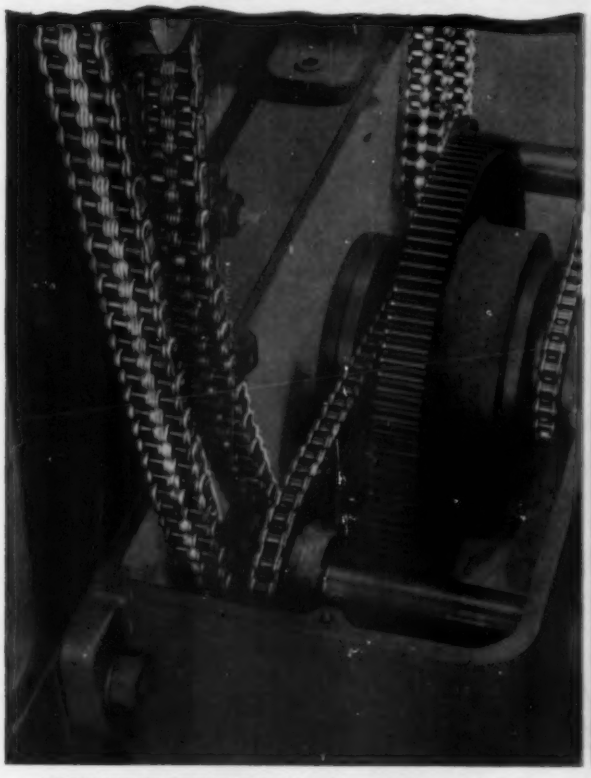
STANDARD PRESSED STEEL CO.

SPS

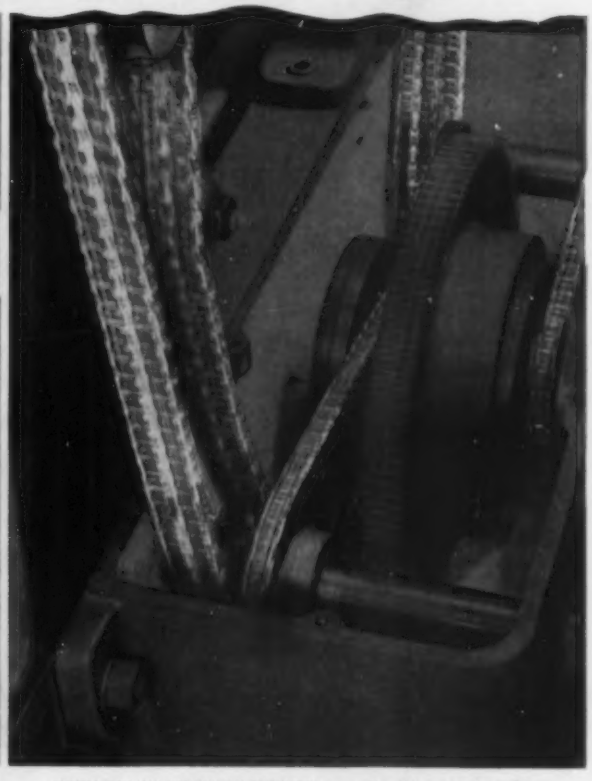
JENKINTOWN PENNSYLVANIA



To static strength . . . add *dynamic strength*



RESISTANCE TO TENSILE STRESS is achieved with properly heat-treated, accurately machined side bars made of premium steel and fitted with properly hardened pins, bushings, rollers.



STRENGTH OF CHAIN IN MOTION results from such refinements as pitch-hole preparation, micro-finish of parts, special processing of side bars, pre-lubrication, rigid quality control.

Why LINK-BELT roller chain takes stresses in stride

ON *tough-service* drives and conveyors, Link-Belt precision steel roller chain consistently delivers longer life. That's because its *greater dynamic strength* withstands the starting shock and centrifugal loads of severe operation.

Reports from users prove the effectiveness of Link-Belt's manufacturing extras that add to greater dynamic strength. Shot-peened rollers give greater fatigue life and ability to withstand impact . . . lock-type bushings end a common cause of chain stiffness . . . pre-stressing provides uniform load distribution . . . closer heat-treat control insures uniformity.

For complete information get in touch with your nearby Link-Belt office.

14,643-A

LINK-BELT

ROLLER CHAIN AND SPROCKETS

LINK-BELT COMPANY: Executive Offices, Prudential Plaza, Chicago 1. To Serve Industry There Are Link-Belt Plants, Sales Offices, Stock Carrying Factory Branch Stores and Distributors in All Principal Cities. Export Office: New York 7; Canada, Scarboro (Toronto 13); Australia, Marrickville, N. S. W.; South Africa, Springs. Representatives Throughout the World.

Great advances in design . . .

NEED THE ADVANCEMENT IN WEAR RESISTANCE PROVIDED BY FLAME-PLATING BY LINDE

Lockheed's F-104A Starfighter, newest weapon of the Air Force, is the most advanced airplane of its type. To give them the greatest possible resistance to extreme conditions, bearing surfaces *(arrows)* of hot air valves used in the F-104A are Flame-Plated with tungsten carbide. Flame-Plating provides the wear-resistant coating needed to withstand the high unit loading and temperature extremes jet plane parts undergo.

Stratospheric altitudes . . . supersonic speeds . . . extreme temperatures subject jet plane parts to almost incredible conditions of heat and abrasion. To assure perfect operation in all circumstances, bearings of hot air valves in the Starfighter are Flame-Plated. A tungsten carbide coating, applied by LINDE's unique method, is the only material tried that successfully eliminated galling and provided a low coefficient of friction over the required service life of the part. With the part Flame-Plated, practically no wear occurred. This LINDE process is now a regular production procedure.

Flame-Plating is LINDE's special process for protecting metal parts from wear, abrasion, and fretting corrosion. Tiny particles of tungsten carbide or aluminum oxide are literally *blasted* onto the metal surface. Since the temperature of the part being coated seldom exceeds 400 degrees F., there is little or no risk of changes in its shape or metallurgical properties. Flame-Plated coatings can be applied from .002 to .010 inches thick, and used as coated or finished to 0.5 microinches rms. Practically all metals can be Flame-Plated—aluminum, magnesium, molybdenum, titanium as well as copper and steel.

Your own design may be improved by Flame-Plating. Find out how, by writing for a copy of the booklet "Flame-Plating," F8065. Address Flame-Plating, Dept. P-9, LINDE COMPANY, Division of Union Carbide Corporation, 30 East 42nd Street, New York 17, N. Y.
In Canada: Linde Company, Division of Union Carbide Canada Limited.

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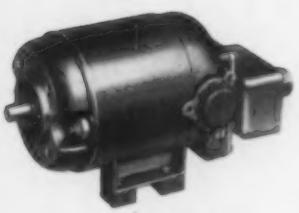
PASSES TESTS WITH FLYING COLORS



Aircraft de-icing pump motor.

Impact concrete drill motor.

Explosion-proof vacuum unit.

Gear motor for slow-speed drive.

If you are interested in any of the above motors write and we shall be glad to send full information.

. . . equal dependability for your product

One of the recent Lamb Electric developments is a motor to drive submerged pumps on military aircraft—for transfer of fuel from reserve to engine tanks.

For such an important application, motor reliability far beyond that normally called for was needed. To insure this degree of reliability in its actual operation of driving the submerged pump, test requirements for the motor were exceptionally rigorous.

As the result of advanced engineering and design, greatly increased brush life, and ability to operate at extremely high temperatures and withstand severe shock tests, the motor passed gruelling tests with flying colors.

The skill and experience exemplified here is available to your company to provide dependable power for *your* new or redesigned products.

THE LAMB ELECTRIC COMPANY • KENT, OHIO

A Division of American Machine and Metals, Inc.

In Canada: Lamb Electric—Division of Sangamo Company Ltd.—Leaside, Ontario

Lamb Electric

SPECIAL APPLICATION FRACTIONAL HORSEPOWER **MOTORS**

WITH THIS RESIN... Firestone EXON 480 RESINS YOU MAKE A BETTER BATCH OF "BISCUITS" EVERY TIME!

EXON 480 ... specifically for (tone perfect) phonograph records

typical of the Pin-Pointed Qualities in Exon Vinyl resins

These "biscuits" are compounded of Exon 480, the vinyl resin created specifically for phonograph records. With each, you get a finished recording of high tonal quality and breakage resistance.

Exon 480 combines many production advantages in the blending, fusing, preforming and molding processes. For instance, here's one production economy: Exon 480's higher bulking density speeds banbury output as much as 25%.

You also get high thermoplasticity, good heat and light stability, plus compatibility with the vinyl plasticizers, stabilizers and pigments most often used. No wonder so many record makers specify Exon 480 for better "biscuits" every time. Another example of how Exon's Pin-Pointed Properties match your particular needs.

Exon 480 is just one of the many fine resins in industry's most complete line of versatile vinyls. It is another reason why industry looks to Firestone Exon for engineered answers to its needs.

Consider your own production or product problem. Then, for resin properties pin-pointed to the best answer for you, check with Firestone.

Firestone EXON RESINS

For complete information and technical service, call or write:

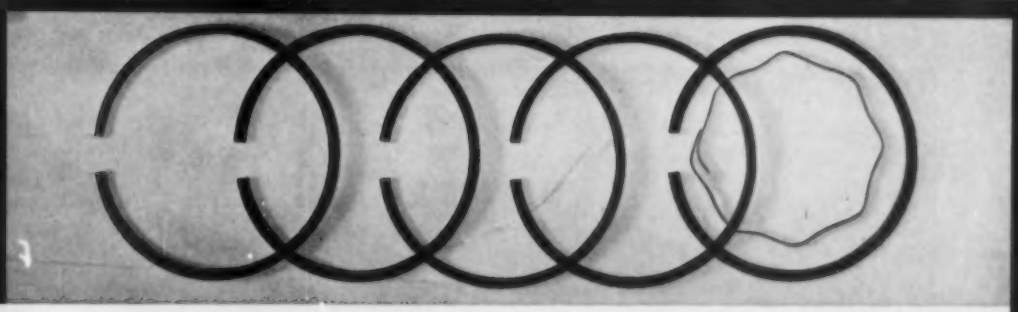
CHEMICAL SALES DIVISION: FIRESTONE PLASTICS COMPANY

DEPT. 76L, POTTSTOWN, PA. • A DIVISION OF THE FIRESTONE TIRE & RUBBER CO.

IN CANADA, CONTACT CHEMICAL SALES DIVISION, FIRESTONE TIRE AND RUBBER COMPANY OF CANADA LTD., HAMILTON, ONT.

INDUSTRY'S MOST COMPLETE LINE OF VINYLS ENGINEERED TO YOUR SPECIFIC NEEDS

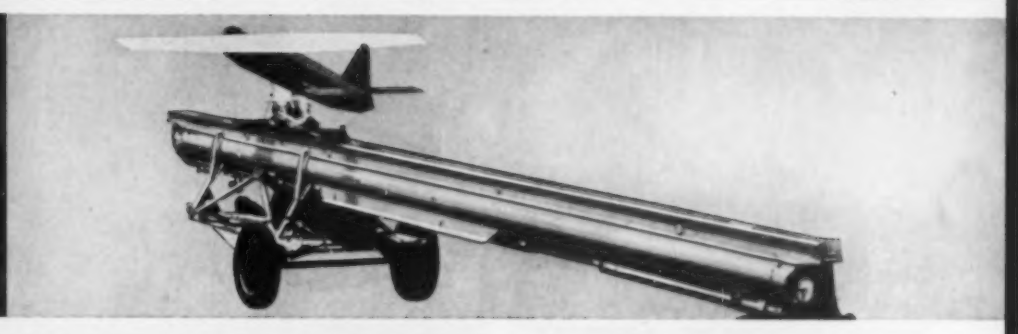
1. Do you recognize the value of these 5 rings?



2. What should a compressor have in common with this freight train?

3. It operates with no impact. Can you name the part?

4. What "fires" this Navy target drone?



WHAT'S YOUR C.Q.? (COMPRESSOR QUOTIENT)

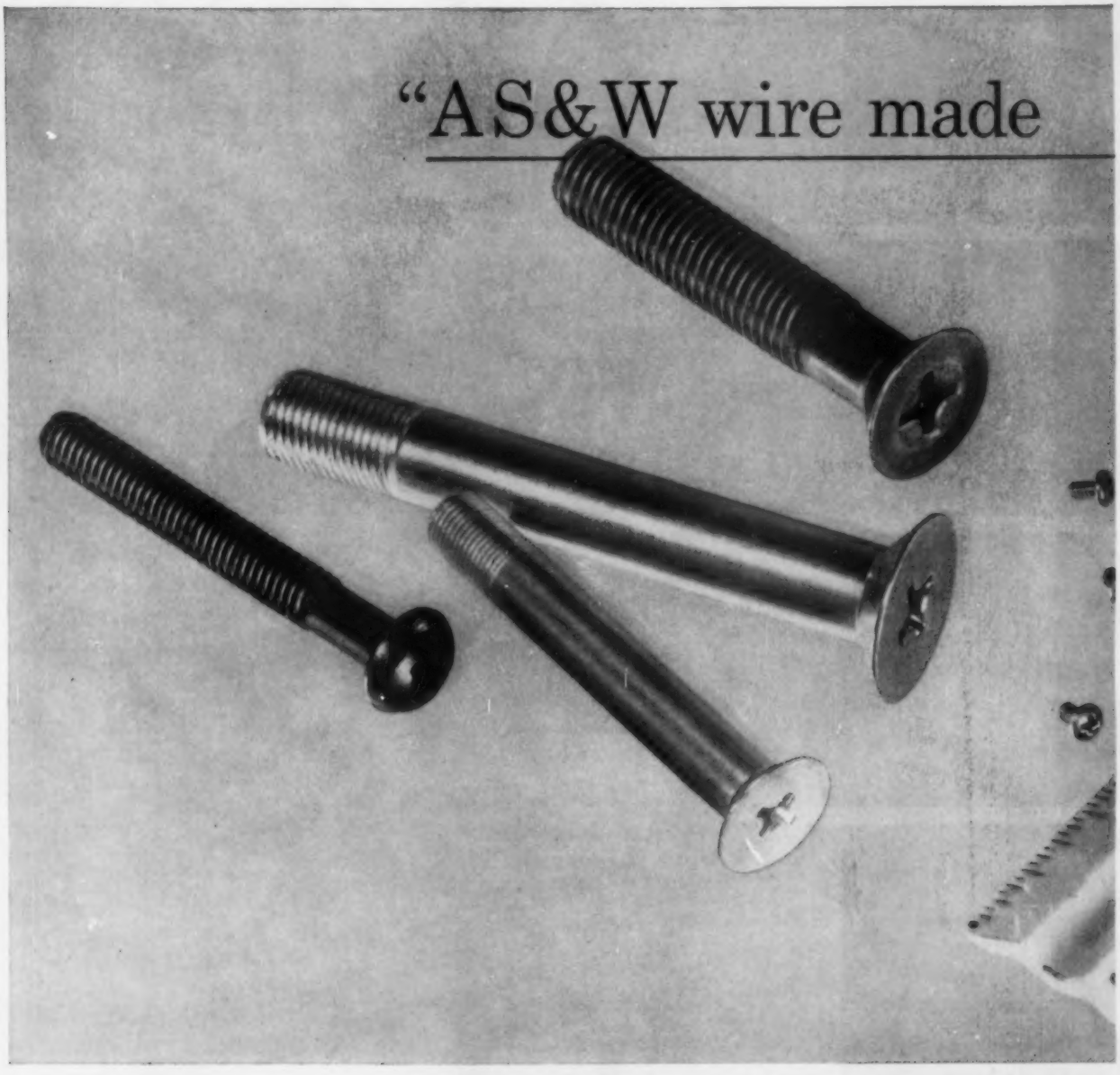
1. You recognize these as being compressor piston rings. But perhaps you didn't know that the number isn't always the same. Many manufacturers, for example, use only four rings. Worthington, however, uses five rings – three compression and two oil. For lower oil consumption, less contamination and higher efficiency, learn to recognize the value of these five rings.

2. To cut maintenance costs, railroads are switching to "roller freight." You'll find tapered roller bearings in all Worthington compressors. Not only do they provide lower friction load, but they also can be adjusted to compensate for wear. To get the best make sure you always specify compressors with "adjustable tapered roller bearings."

3. When operating, the valve strip shown above opens and closes with a gentle rolling contact – there's no destructive impact. Replacement is infrequent and unlike many other makes which require replacement of the complete cylinder or head, all Worthington compressors are equipped with individually replaceable valves, valve guards, and valve seats. This feature saves many maintenance dollars.

4. Developed by Van Zelm Associates of Baltimore, the Navy's new mobile catapult is "fired" by compressed air supplied by a 20-hp Worthington compressor. As true in industry as it is in defense whenever men need reliable compressed air they turn to the company with a reputation for performance. Worthington Corporation, Harrison, New Jersey. PC. 7.13

WORTHINGTON



Some typical Phillips head fasteners. Notice the well-defined Phillips punch impression, made with one blow in cold steel.

Typical bank of cold-heading machines. Impression of the Phillips punch is such a severe operation that punches may last from one to several hours.

Phillips fasteners possible,"

says AMERICAN SCREW COMPANY
WILLIMANTIC, CONN.

AMERICAN SCREW COMPANY is the largest manufacturer of recessed head fasteners. They produce several million pieces a day, in thousands of different varieties, using many tons of highest quality cold-heading wire.

We're all familiar with the Phillips head fastener. Consider for a moment the production problems involved in making it. In a high-speed, two-blow, cold-heading machine, the wire is cut and cold forged into a blank in the first operation. Then, in the second step, the preformed head is impressed with the Phillips punch. The wire must be hard enough not to buckle; but at the same time, it must be soft enough to flow and fill out the head without splitting—even when the Phillips punch slams into it.

For years, we worked to develop a wire that would withstand the relentless pounding of the Phillips cold-heading machines. We developed a highly engineered method of annealing the wire, then drawing it slightly to work-harden it. It was hard on the outside (no buckling), soft on the inside (easy flowing), clean as a whistle and free from surface imperfections.

We would be tempted to say that this was strictly an American Steel & Wire development . . . but it wasn't. Factually, the development of "Phillips Quality Wire" was a cooperative effort between the men at AS&W and American Screw. It took a long time, but it paid off with beneficial results that have radiated to every industry that has a fastening problem.

There is nothing we'd like better than a chance to cooperate with you to help work out some of *your* wire problems. Just call your AS&W salesman.

AMERICAN STEEL & WIRE DIVISION
UNITED STATES STEEL, GENERAL OFFICES: CLEVELAND, OHIO
COLUMBIA-GENEVA STEEL DIVISION, SAN FRANCISCO,
PACIFIC COAST DISTRIBUTORS • TENNESSEE COAL & IRON DIVISION,
FAIRFIELD, ALA., SOUTHERN DISTRIBUTORS
UNITED STATES STEEL EXPORT COMPANY, NEW YORK

Checking a coil of AS&W "Phillips Quality Wire." All wire is bought to finished size. It is shipped coated, ready for heading.

USS AMERICAN MANUFACTURERS WIRE

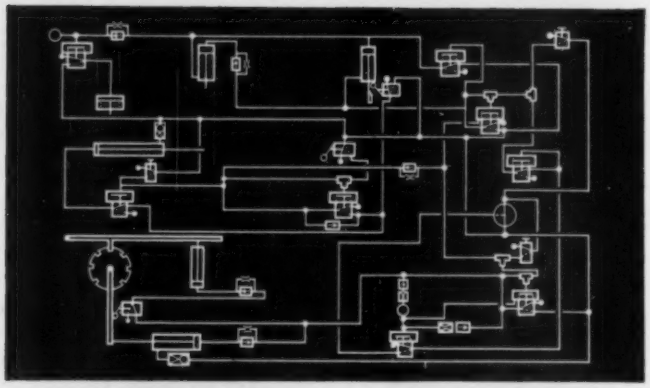
USS

AMERFINE —*high-quality fine wire.*
AMERSPRING —*music steel spring wire.*
AMERTEMP —*heavy-duty oil-tempered wire.*
AMER-LED —*leaded steel.*
AMERLOY —*alloy heading wire.*
AMERHEAD —*uniform heading wire.*
AMERSTITCH —*extra-tough metal stitching wire.*
STAINLESS STEEL —*wire and strip.*

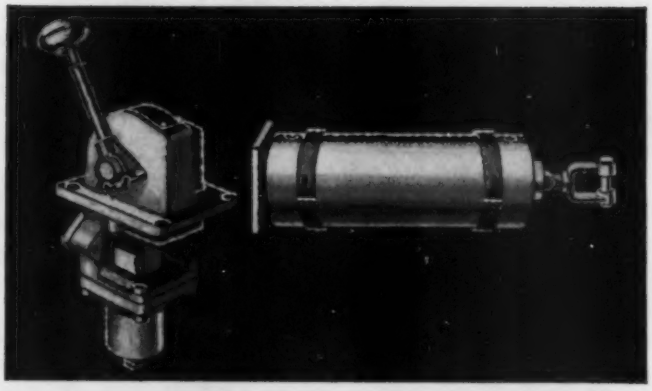
UNITED STATES STEEL

Get them all

pneumatic engineering



pneumatic control equipment



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89 YEARS OF EXPERIENCE—Practically since the beginning of the use of air to control mechanical operations, Westinghouse has been designing, building and improving pneumatic control systems. The benefit of this long experience is yours when you specify Westinghouse Pneumatic Control. Pneumatics specialists are available to help you with design or application problems.

A COMPLETE LINE—From simple on-off devices, to flow-control valves, to cylinders, to relay valves, to *pressure*-control valves with which you can combine 3 or more functions in a single lever. All are built with the ruggedness and supreme reliability needed to keep them on the job for years in hard service. And all are available from one experienced manufacturer—Westinghouse Air Brake Company.

GOOD DELIVERY, GOOD SERVICE—From Westinghouse, you get not only distributor service, but also comprehensive engineering service from qualified factory experts. Parts or service are available anywhere in the world—from affiliated Westinghouse companies overseas. Send the coupon for more information on modern uses of pneumatic control.

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Confidence—the world over

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FREE PNEUMATIC CONTROL DATA—Here, in this new booklet, you will find basic fundamentals of pneumatic control engineering written clearly, concisely and with the authority of Westinghouse's 89 years of experience in this field. Send the coupon for a free copy. We'll also send you examples of recent applications of Westinghouse Pneumatic Control—applications which will show you the versatility of modern pneumatic control.

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Industrial Products Division, Dept. PE-97
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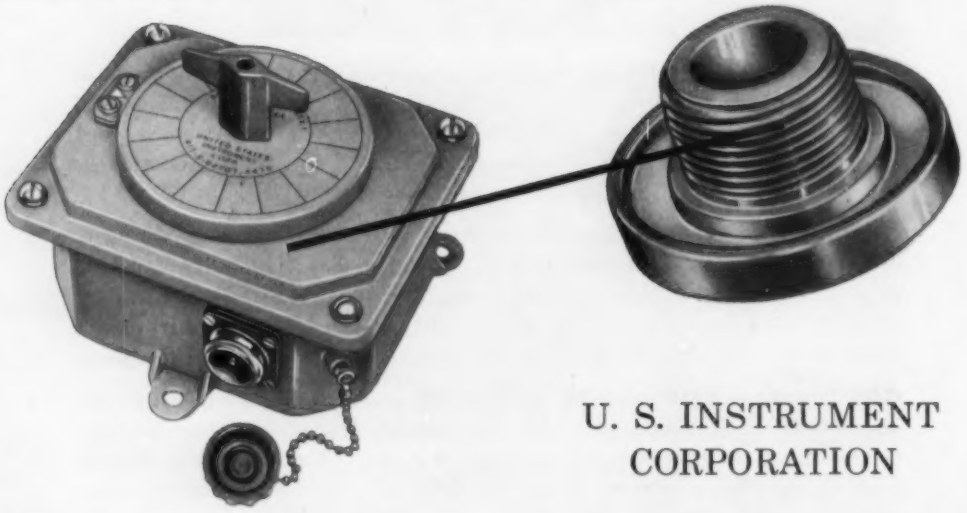
CITY ..... STATE .....

Three more nationally known manufacturers select Mueller Brass Co. Forgeable Bearing Alloys for vital components of their products

In ever-increasing numbers, Mueller Brass Co. specialized alloys are being specified by manufacturers of top-quality products. In a series of continuing advertisements, we have presented case histories of successful applications, to which we now add three more distinguished companies who are incorporating Mueller Brass Co. forgeable bearing alloys in their products to meet the demands of widely divergent operating conditions.



U. S. INSTRUMENT CORPORATION

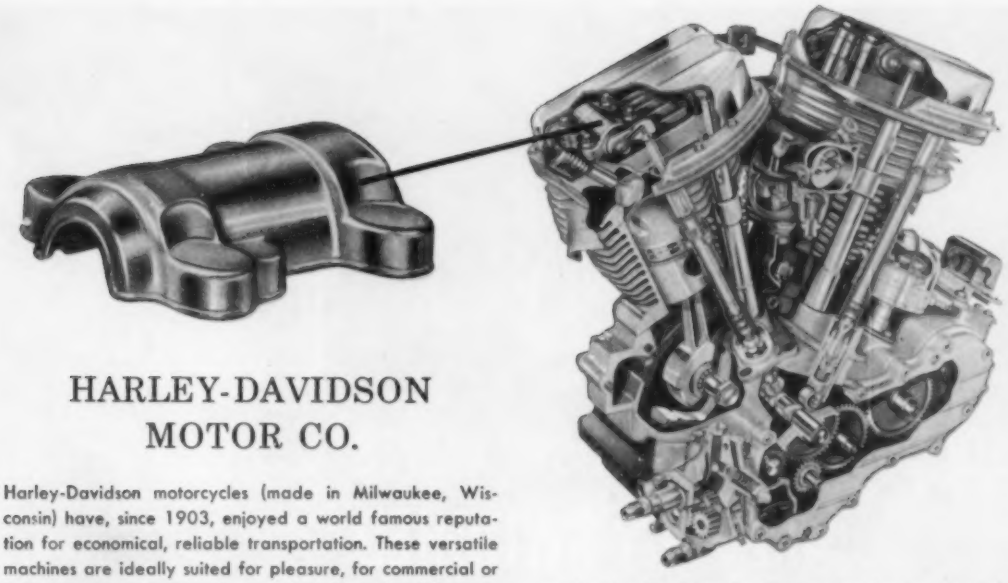
U. S. Instrument Corporation, Charlottesville, Va., selected abrasive-resistant Mueller bronze alloy bushings for their remarkable telephone selector switches after exhaustive tests of many materials. A vital communications link on today's U. S. Naval vessels, these sound-powered telephone circuits must meet rigid Navy performance-standards. Such phones, for example, must have selector switches which are capable of rotating for a minimum of 50,000 torturous cycles . . . 360° clockwise, followed by 360° counter-clockwise. In addition, the "O" ring must still form a water-tight seal AT THE END OF THE TEST! Of the many tested, a Mueller Brass Co. special manganese bronze alloy was the best one meeting these rigid specifications.

There were other important reasons why these bushings were chosen by U. S. Instrument Corporation for this application. Resistance to abrasive action against the rubber "O" ring was a prime one . . . then, too, the stem assembly suffered severe pounding through the action of the indexing mechanism which, prior to the use of the Mueller Brass Co. alloy, caused repeated seizure of the component parts. In this particular application, the part was fabricated on an automatic screw machine rather than produced as a forging. The versatility of Mueller Brass Co. alloys makes them readily adaptable to the most economical method of fabrication dependent upon the size, shape, and end-use requirements of the part.

In commenting on the success of this part, U. S. Instrument Corporation praised the alloy for its tensile strength (ordinary brasses could not withstand the 2000 ft. lb. impacts without deformation), for its machinability and corrosion-resistance.

40 MUELLER BRASS CO. UNIT 1917

MUELLER BRASS CO.



HARLEY-DAVIDSON MOTOR CO.

Harley-Davidson motorcycles (made in Milwaukee, Wisconsin) have, since 1903, enjoyed a world famous reputation for economical, reliable transportation. These versatile machines are ideally suited for pleasure, for commercial or business use, as well as the grueling demands of law enforcement work. Harley-Davidsons boast a dependable engine . . . one which can roll up an astounding mileage record with little or no care. The painstaking selection of every engine component is one important reason for this reliability. The new twin-cylinder Harley-Davidson 74 OHV employs Mueller Brass Co. bronze alloy forgings in the form of rocker-arm bearing caps. Subjected to violent temperature changes, fast starts and stops and road shock, Mueller forgings are proving again and again that they have the ability necessary to withstand almost any punishment . . . and still provide unfailing service.

JACOBSEN MFG. CO.

Jacobsen Mfg. Co., Racine, Wisconsin, was among the first to produce a practical power mower for home use. That was more than 35 years ago! Today, Jacobsen power-mower dependability is evident itself in more than a dozen gleaming new models such as the popular Pacer, Lawn Queen, Manor and others. One of the most reliable components in the always dependable Jacobsen hi-torque engine is a Mueller Brass Co. connecting rod forged from special bronze alloy. Jacobsen mowers with Mueller-forged connecting rods are called upon by some commercial users to operate as much as 8 hours daily, 6 days a week . . . perhaps as much as 2000 hours a year. In searing summer temperatures, thru hours of constant operation, the high uniform strength of Mueller bronze forgings constantly withstands pounding and vibration with the same conspicuous success as in its many other applications.

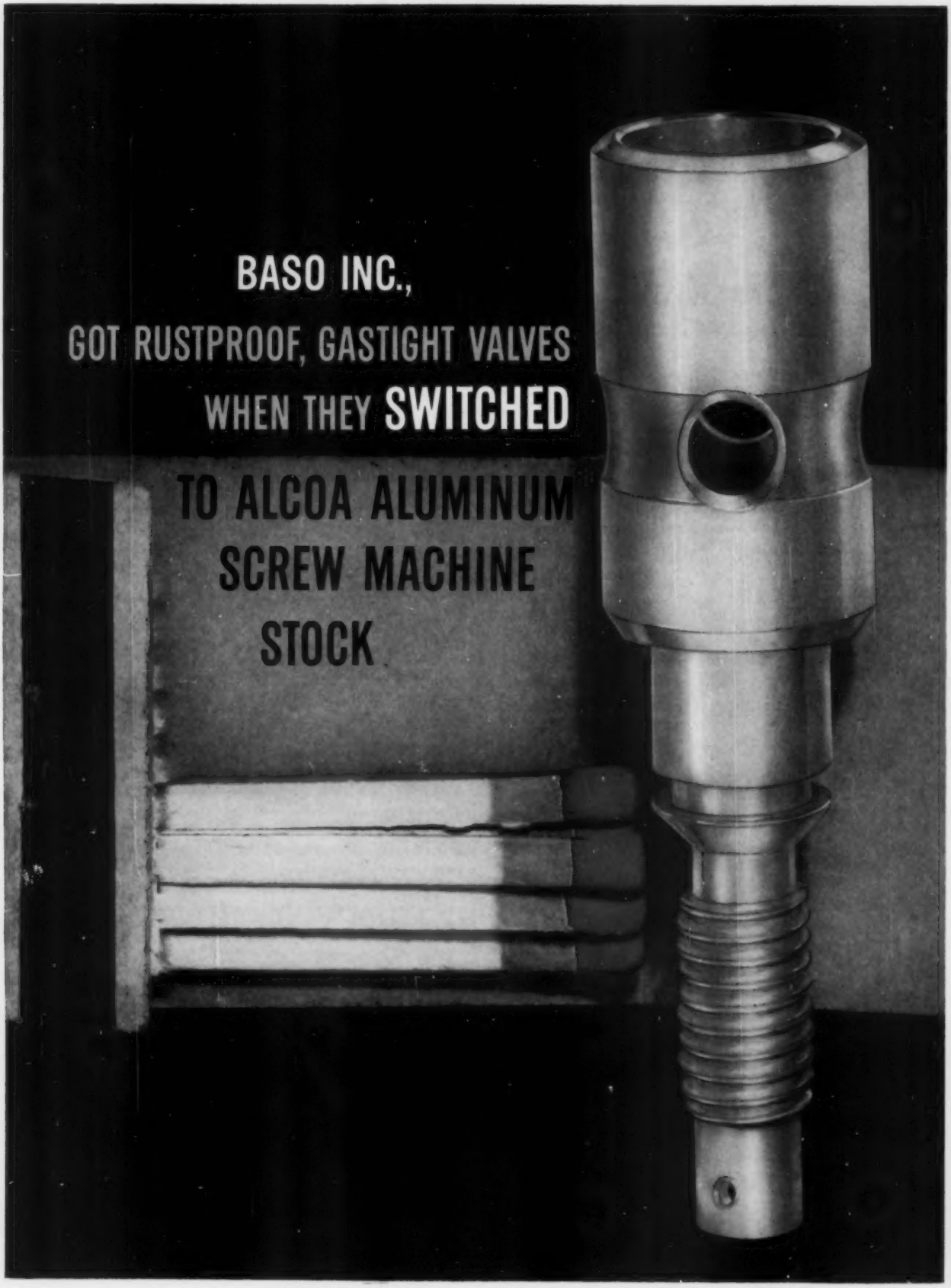
Why not investigate these specialized alloys for your own products. We welcome your inquiries. Our engineering staff will be happy to make specific recommendations. Both on the proper alloy and the best method of fabrication to meet your needs . . . exactly. Our engineering manuals show many, many examples of how American manufacturers have used these alloys to great advantage.

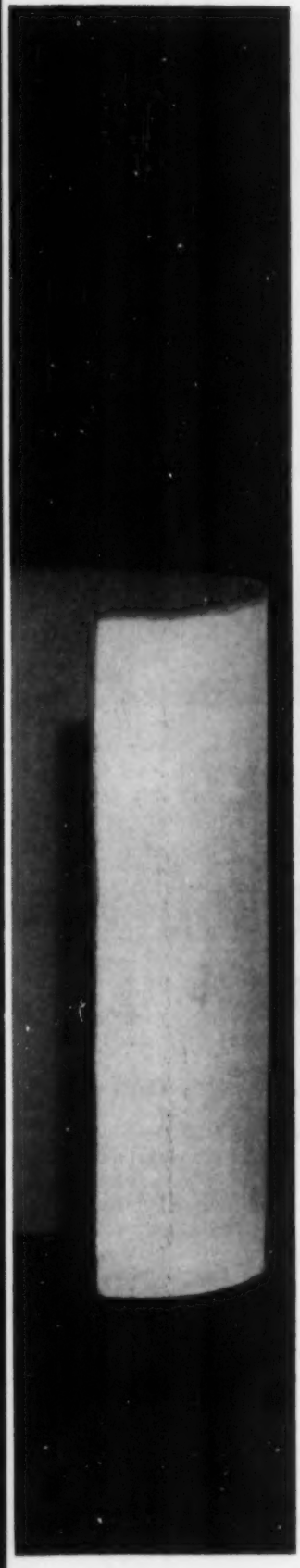
• WRITE TODAY FOR THE ENGINEERING MANUAL YOU NEED

- **Mueller Brass Co. Forgings** Engineering Manual H-58565 ☐
- **Tuf Stuf Aluminum Bronze Alloys** Engineering Manual H-58563 ☐
- **"600" Series Bearing Alloys** Engineering Manual FM-3000 ☐
- **Copper Base Alloys in Rod Form** Engineering Manual FM-3010 ☐

227

PORT HURON 22, MICHIGAN


BASO INC.,
GOT RUSTPROOF, GASTIGHT VALVES
WHEN THEY SWITCHED
TO ALCOA ALUMINUM
SCREW MACHINE
STOCK



Baso Inc., pioneered the thermoelectric controls that make wonderful things happen in America's homes. Gas ranges, clothes dryers, heating units turn themselves on and off automatically.

Brass was formerly used for Baso valve cocks, but these parts were converted to aluminum in conjunction with a complete switch to aluminum for valve bodies. This change entirely eliminated any corrosion problem that might occur between dissimilar metals. With one pass of a single-point tool, Baso gets a surface finish of 16 micro inches in a cycle time of 18 seconds (machine capacity). The lapping operation required with brass was eliminated and so were gaskets, for the metal-to-metal aluminum seal proved to be gastight.

If you machine parts from steel or brass, now is the time to take a hard look at these economic facts about aluminum:

1. Aluminum costs less than brass, and machines just as fast.
2. Aluminum machines faster than steel and won't rust.
3. Aluminum scrap allowance is high.

Now is the time to switch to Alcoa® Aluminum. To help you make that switch, call on your nearest Alcoa sales office. For immediate delivery of screw machine stock, contact your nearest Alcoa distributor. ALUMINUM COMPANY OF AMERICA, 865-J Alcoa Building, Pittsburgh 19, Pa.

IN DESIGN

Russell Matthews, Director of Product Engineering (left), discusses aluminum backing for valve facing with James Dowd, Director of Industrial Engineering. Mr. Matthews says, "Alcoa helped us start redesigning with aluminum back in 1948. Our conversion from brass is now complete."

IN PURCHASING

Mr. G. C. Winters, Director of Purchasing, says, "We have never had to reject Alcoa stock either from the mill or from its local distributor. We find both very cooperative in making deliveries to meet production schedules, thereby saving us warehouse space."

Visit the Alcoa-National Acme Cooperative Machining Demonstration, National Acme Company, Cleveland, Ohio, September 10 and 11, 1957

ALCOA ALUMINUM SCREW MACHINE STOCK

WE CHOSE ALCOA ALUMINUM SCREW MACHINE STOCK

* **LEARN WHY OTHER COMPANIES HAVE *SWITCHED TO ALCOA ALUMINUM***

Direct quotes from leaders in industry on why they buy from Alcoa. Fill out coupon for your copy.

Name_____

Title_____

Company_____

Address_____

City_____ State_____

Urethane rubber mallet head is so tough it can drive spikes through 2 x 4 without damage, yet so resilient a similar blow will not mar a polished table top.

New Urethane Material Combines Bounce of Rubber With Toughness of Metal

Resistance to high and low temperatures, common solvents, grease and oil make urethane rubber a natural choice for diaphragms, reservoirs and pump parts for industrial equipment.

. . . Gives Up To 10 Times The Wearability of Ordinary Rubber.

An entirely new kind of rubber, classed as a chemical elastomer, is being evaluated as the first elastic material that can qualify as a replacement for metals and plastics in industrial uses where a high degree of hardness must be combined with good flex fatigue resistance, exceptional toughness and wearing abilities.

Urethane rubber, a high polymer discovery of Farbenfabriken-Bayer, A. G., has been brought to the stage of commercial development in this country by Mobay, which is jointly-owned by Monsanto and Bayer. In commercial application tests, the new material exhibits such a broad range of desirable engineering properties, plus unusual versatility in the way such properties as hardness and elasticity can be combined, that product engineers in many basic industries see in it the key to radical design changes in the industrial equipment field.

In one functional area, particularly, the triumph of urethane rubber over conventional rubber materials seems complete. In direct contrast to natural and other synthetic rubbers, the tear strength and abrasion resistance of the urethane product increases in almost direct proportion to the hardness

In addition to exceptional strength and abrasion resistance, the ease of casting urethane rubber in parts with difficult undercuts, slots, inserts and threads puts this material in the "work horse" category for designers and engineers.

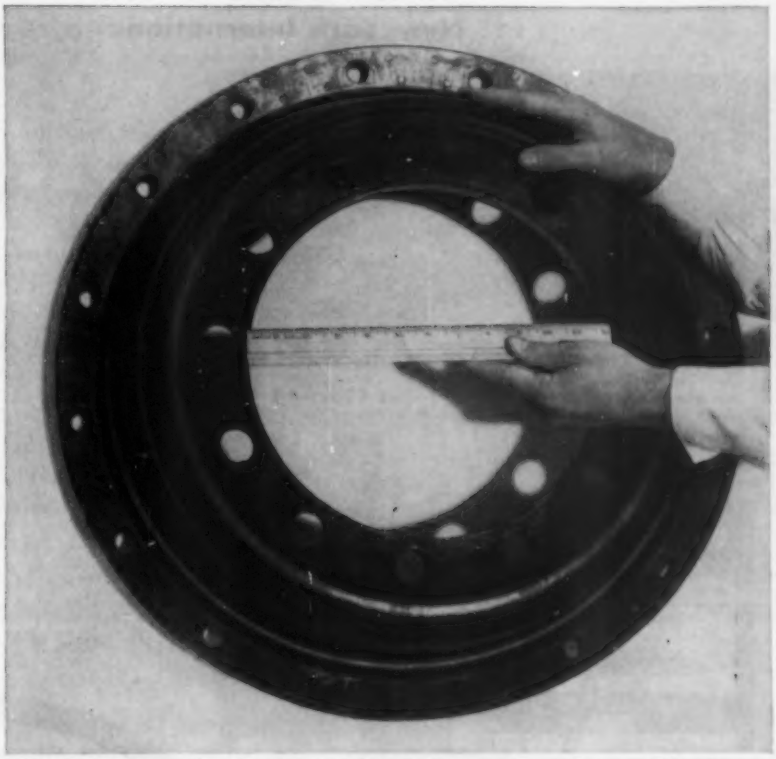
A high degree of flexibility and extraordinary tensile strength are among properties which may be combined for drive belts. Low abrasion loss, lower noise level and high coefficient of friction are additional advantages.

factor. In controlled laboratory tests, urethane rubber with a hardness value of 78-83 Durometer (Shore A Scale) was found to provide from three to ten times the wear resistance of other rubber materials in the same category.

In ordinary rubber, toughness is increased by blending in fillers which deaden elasticity, and by use of fibers which increase cost and reduce working properties. In contrast, the toughness of urethane rubber is achieved by modifying the molecular structure of the material itself which imparts an inherent stability to the end-product and makes precise quality control possible.

The superiority of urethane rubber over other types of rubber is unmistakable . . . in rebound elasticity, high and low temperature strength, elongation, resistance to solvents, ozone, acids and oxygen; in electrical properties and dielectric constant . . . and in other properties of interest in specialized manufacture.

Urethane rubber can be cast or machined to meet specifications for almost any configuration or contour, for such uses as oscillating bearing surfaces, automotive suspension systems, ball-joint assemblies, gears, grommets, vibration dampening devices, tools and industrial truck tires. Its exceptional strength and toughness make it an alternate choice for metals, in many cases, as well as an improvement over molded nylon and other rubber materials.



Huge flanged coupling for ship's drive shaft, cast of urethane rubber in one piece without reinforcement, will outwear ordinary materials many times.

For further information, technical assistance and sources of supply for urethane rubber, write to: Mobay Chemical Company, P-2, St. Louis 4, Mo.

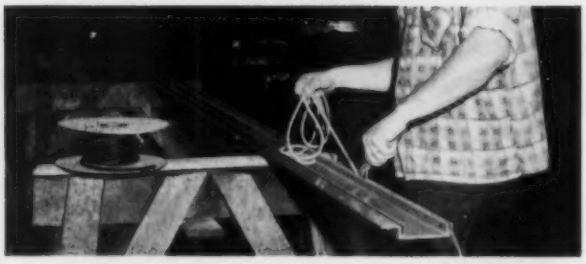
MOBAY
First in Urethane Chemistry

FLOUR CITY ORNAMENTAL IRON REPORTS 30% SAVINGS WITH RUBATEX

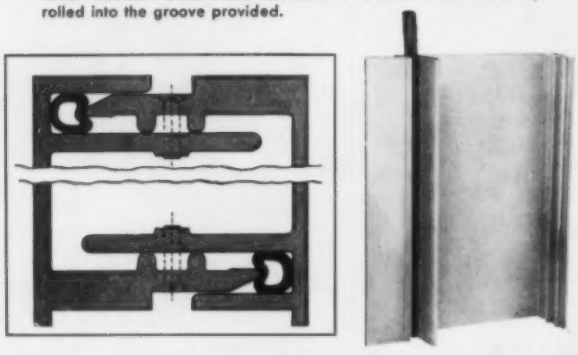
Scale model view of 11-city-block-long International Arrival Building under construction by The Port of New York Authority in its $90,000,000 "Terminal City" at New York International Airport. Aluminum window frames (4'x16' and 8'x25') on second floor level and in control tower fabricated by The Flour City Ornamental Iron Company of Minneapolis.

Rubatex Neoprene Cord and Tubing used as sealing and expansion member in window frames . . . selected because of its long life expectancy—its flexibility and resistance to chemical fumes.

Used as sealing and expansion member in aluminum window frames for International Arrival Building at New York International Airport



Rubatex Neoprene Cord forms a positive seal in the extruded section of the window frame. G. M. Grady, Vice President and Chief Engineer of Flour City, says "Savings of 30% are realized in this application as compared against calking compound usually used." Rubatex Cord is coated with talc as a lubricant and easily rolled into the groove provided.



Rubatex Neoprene Tubing is necessary because of the difference in expansion and contraction between the aluminum and steel. Structural blueprint and photo show how Rubatex Tubing is effectively used as an expansion member.

Rubatex's uniform size, ability to return to original dimension after extended pressure, plus its closed cellular zero moisture absorption and complete oxidation resistance make it ideal for this unusual window frame application. In addition, Rubatex Cord is used for weather stripping, appliance, instrument and automotive gaskets and drum seals. Rubatex Tubing makes a positive moisture-proof insulation for any formed tubing cold line application.

Rubatex Cord produced in continuous lengths in 1/8" to 1/2" diameter. Can be supplied in polymers other than neoprene. Other extruded shapes can also be furnished.

Rubatex Tubing available in standard inside diameters of 1/4" up to and including 2" with 3/8" and 1/2" wall thickness. Other sizes can be made to specifications.

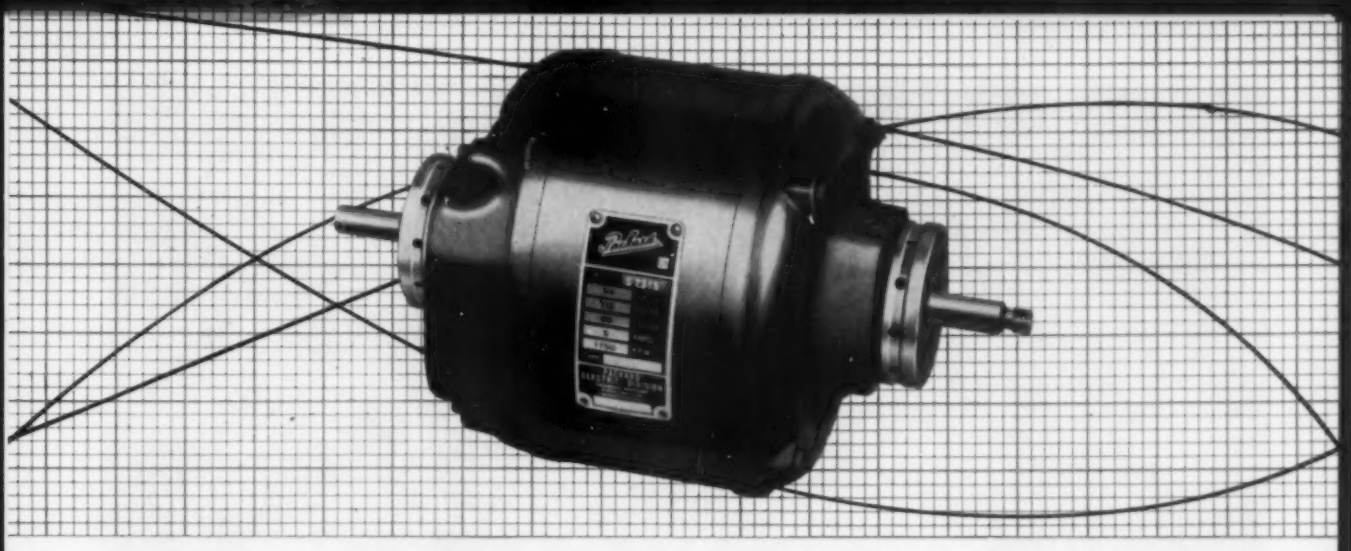
RUBATEX DIVISION, Dept. P-8
GREAT AMERICAN INDUSTRIES, INC.
Bedford, Virginia

For full details and sample of Rubatex Neoprene Cord and Tubing—print your name in space below, attach to your company letterhead and mail to us.

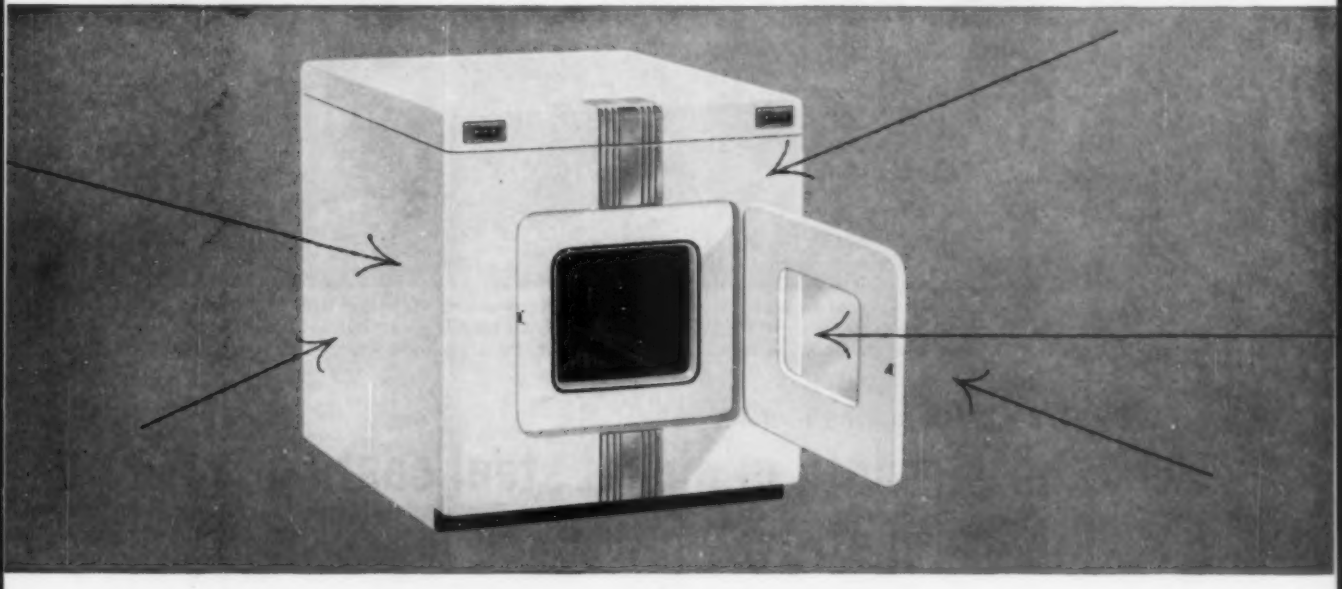
Name_____

RUBATEX
NEOPRENE CORD AND TUBING

Send for Free Sample and full details



PACKARD ELECTRIC / *Because this motor was custom-tailored*



FHP MOTORS / *this dryer is built better at lower cost!*

Packard Electric direct factory sales and engineering contact consistently pays off. In this case it did for a dryer manufacturer.

The payoff came in a motor custom-tailored to dryer requirements . . . not merely a conveniently adapted motor. This means that the motor has the exact characteristics—speed, power and torque—for its job. Because of that, it could be advantageously priced.

What's more, it can be supplied with power supply cord already attached—complete and ready for installation. This results in still more savings.

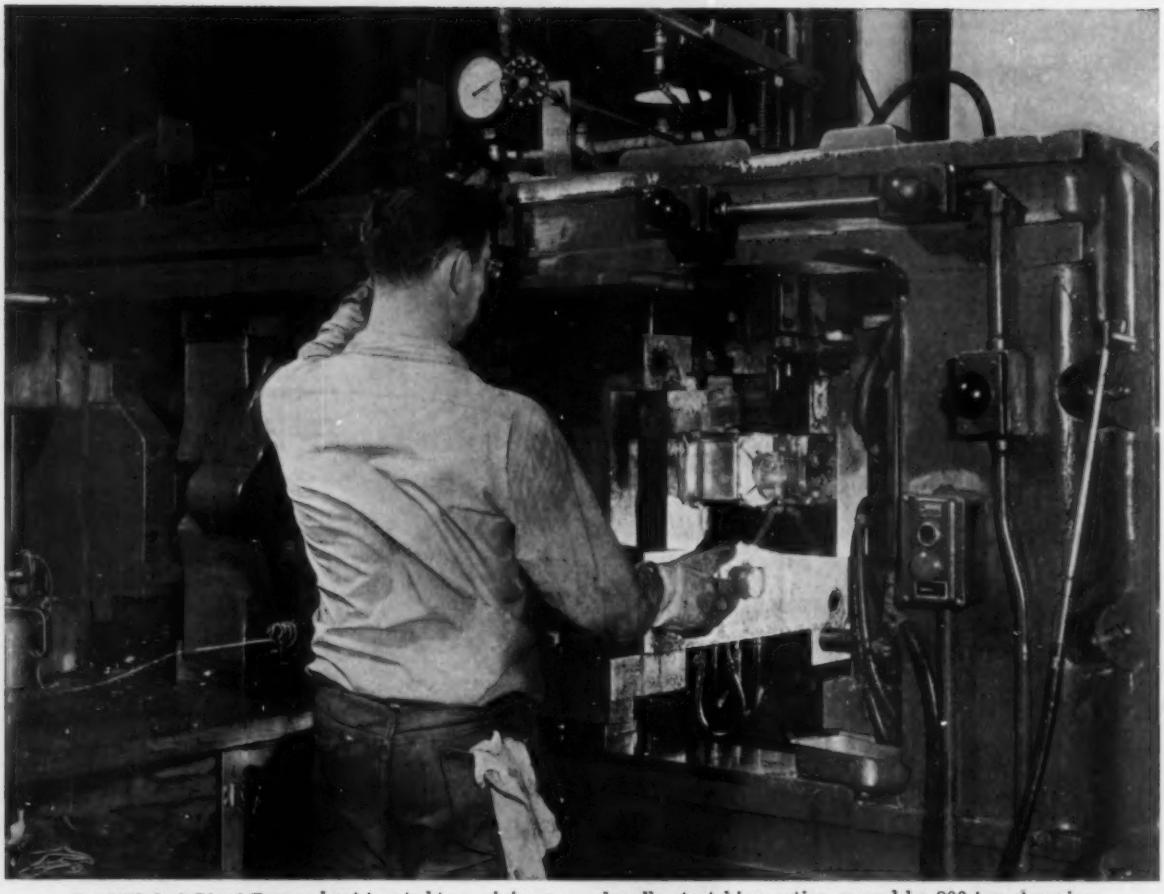
Packard Electric research and engineering teams are busy today developing new motors. And as always, our objective is to enable customers to produce better, lower priced products in the future.

Packard Electric

Warren, Ohio

GM GENERAL MOTORS

Division of General Motors



Cast Nickel Steel Frame heat treated to a minimum tensile strength of 100,000 pounds per square inch, yield strength of 80,000, provides properties needed to handle stretching action caused by 800-ton clamping force. This 40,000-pound die casting machine was built by Lester Engineering Company, Cleveland, Ohio.

Stretches with no permanent set...

High strength of nickel steel casting boosts life of repetitively stressed machine frame

The cast nickel steel frame on the die casting machine above accepts and recovers from a clamping force of 800 tons 100 times-an-hour... round the clock!

This punishing stress cycle caused Lester Engineering Company, builder of the machine, to discard four differently designed frames fabricated from mild steel. The firm then switched to a nickel steel frame casting which has proven completely dependable.

On the basis of this performance, Lester Engineering has standardized on cast nickel steel frames for its entire line of plastic molding and metallic die casting machines.

For high strength, toughness and impact resistance

Nickel steel castings offer a combination of properties that might be the key you have been looking for to improve performance and service life of your own machines and machine tools.

For a look-see on how you can take advantage of the properties of nickel steel castings, send for your copy of "Nickel Alloy Steel Castings in Industry."

And remember

INCO NICKEL ... brings you

INCO+SERVICES

Whenever you are looking for answers to your metal problems, all the information and help we can give you are yours for the asking. For instance ...

- **+ Corrosion Service**
- **+ High Temperature Service**
- **+ Casting Information**
- **+ Field Information Centers**
- **+ Technical Publications**

INCO TRADE MARK

THE INTERNATIONAL NICKEL COMPANY, INC. 67 Wall Street New York 5, N.Y.

1. Better Lubrication — Less Machine Down Time

MICRO-FOG lubrication automatically coats all the bearings, gears, chains and other components of a machine with a continuous, protective film of clean oil. Just the right amount of oil is applied to provide the most efficient lubrication, reducing wear on machine components and cutting maintenance and replacements costs.

2. Oil Always Fresh, Always Clean

There is no recirculation of deteriorated or contaminated lubricant to cause wear or corrosion. Clean oil is applied continuously to all lubrication points in carefully metered amounts.

3. For Large and Small, Plain and Anti-Friction Bearings

MICRO-FOG Lubricating systems have found enthusiastic acceptance for use on all types of machinery, ranging from *high speed* grinders to huge roll mill bearings on shafts as large as 34" in diameter and turning at relatively *low speeds*.

Why COST CONSCIOUS men are choosing Norgren MICRO·FOG

4. Centralized, Automatic Lubrication

A single, MICRO-FOG Lubricator will automatically deliver enough airborne lubricant, proportionately distributed to completely lubricate even a large machine tool. Only one lubricator to maintain and refill.

5. Big Savings in Lubricant

Carefully metered quantities of oil are applied to each lubrication point. MICRO-FOG provides more thorough lubrication using only a few ounces of oil per day than other methods using several gallons of oil per day.

6. Bearings Run Cooler

Air passing through the bearing carries away heat, and there is no pool of lubricant in the bearing to generate heat as a result of fluid friction. Lubrication is continuous — there are no periods of insufficient lubrication with metal wearing on metal.

For Lubricating

- BEARINGS
- GEARS
- CHAINS
- SLIDES
- WAYS
- OTHER MACHINE COMPONENTS

7. Contaminants Excluded From Bearings

A slight positive pressure is maintained within the bearing, and air continuously escapes from the bearing, preventing the entrance of contaminants from the surrounding atmosphere.

8. Fewer Bearing Seals Required

Because MICRO-FOG must be vented to the atmosphere, it is not necessary to maintain tight seals. Fewer oil seals are required, reducing maintenance and machine down-time.

9. Oil Filters, Sumps and Pumps Eliminated

The quantity of lubricant used in MICRO-FOG Lubrication System is so small that there is nothing to reclaim or recirculate. Expensive high pressure piping is also eliminated.

10. Automatic Alarm Controls

MICRO-FOG Lubricators are available with switches to actuate an alarm system or controls as a warning of conditions affecting proper lubrication.

11. Visible Oil Feed

The oil feed is readily visible on all models of MICRO-FOG Lubricators, providing positive proof that the lubricator is operating properly.

12. A MICRO-FOG Lubricator For Every Size Machine

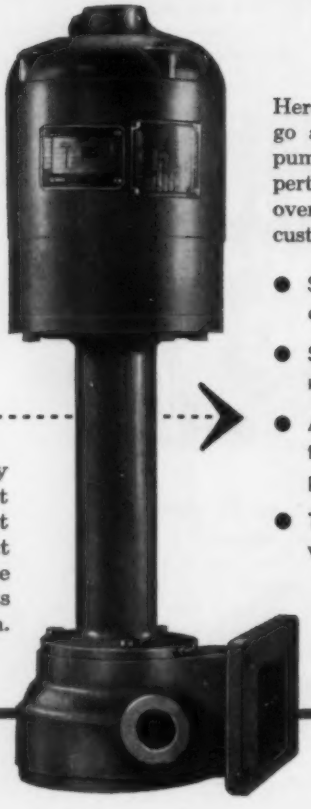
19 models to choose from—ratings up to 1,000 bearing inches and oil reservoir capacities up to 4½ gallons.

For complete information, call your nearby Norgren Representative, or WRITE FOR NEW 800 CATALOG.

C. A. NORGREN CO.

3428 SO. ELATI ST., ENGLEWOOD, COLORADO

MORE dependability with Allis-Chalmers Coolant Pumps



Here's a complete line of coolant pumps made to go and go on the equipment you build. These pumps have been designed by Allis-Chalmers experts in viscous liquid pumping and will contribute, over the long run, to repeat business from your customers. **Here's why:**

- Sturdy cast iron casing encloses entire unit to assure continued accurate alignment.
- Single-shaft construction maintains maximum rigidity, providing ultimate in bearing life.
- A variety of sealing arrangements are available that need no maintenance nor adjustment once pump is installed.
- The bearings are sealed and operate for years without attention.

These features and many others make A-C pumps right for your application. Find out more from your A-C district office or distributor, or write Allis-Chalmers, General Products Division, Milwaukee 1, Wisconsin.

This Coolant Pump model is sidewall mounted, is sealless and has open impeller.

Available in fractional and integral hp sizes, above model is designed for mounting on vertical surface.

Vertically Mounted on liquid reservoir, this design operates efficiently with varying liquid levels.

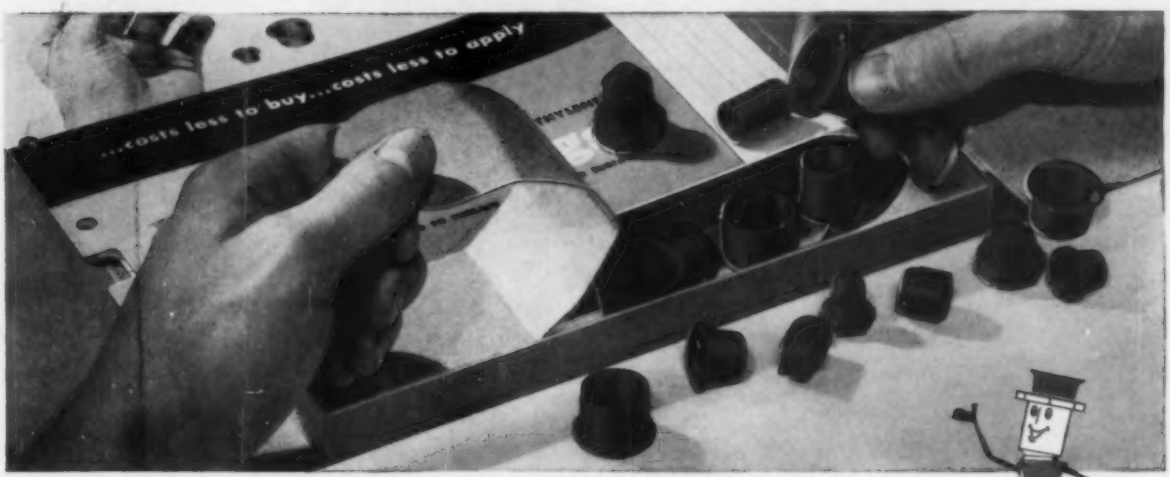
Submerged Mounted, this type of pump is frequently used on machines requiring mounting in coolant tank.

Shallow Pump or reservoir use is ideal for this submerged mounted model featuring a sealless design.

ALLIS-CHALMERS

A-5360

which **CaPlug** will protect <u>your</u> product best?



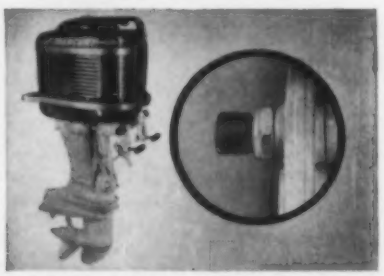
write for this free sample kit and see!

WANT TO SEAL OPENINGS IN A JIFFY?

Tapered (non-threaded) CaPlugs can be used as caps or plugs, inside and outside of threaded or plain fixtures. Just push them on . . . or push them in. Costing less to buy, these versatile closures cost less to apply. Time studies show that tapered CaPlugs save up to 500% in labor costs.

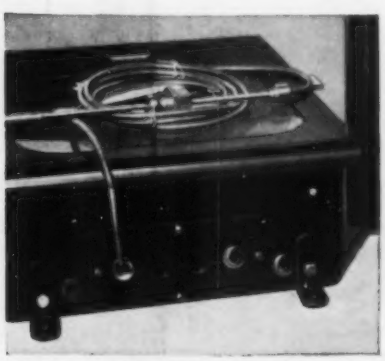
WANT TO KEEP FITTINGS UNDER WRAPS?

See how CaPlugs seal out dust and protect fittings of this refrigeration valve during shipment. Says Automatic Machine Products Sales Co., "It is important that the valve be free from contamination, since a large percentage of refrigeration systems are hermetically sealed and guaranteed for five years. CaPlugs are easy to install and afford the protection we desire."



WANT TO PROTECT DELICATE THREADS?

Kiekhaefer Corp. guards the threads on the "Ride Guide" steering controls of its Mercury outboard motor with *threaded style* CaPlugs. Here's long-lasting protection . . . the customer can reuse the CaPlugs when storing his motor. Made of tough, flexible Polyethylene, CaPlugs are especially kind to threads and polished surfaces — will not collapse, chip, break or shred.



WANT TO ADD SALES APPEAL?

Colorful CaPlugs spruce up your product and reflect the care you have taken to keep delicate systems free of dirt, moisture or foreign matter. This Bristol air control instrument is a good example. Says The Bristol Company, "They are sturdy enough so that they are not accidentally dislodged, but are still easily removable."

CAPLUGS FIT PRACTICALLY ANY CLOSURE NEED YOU CAN NAME.

Ten standardized designs (both threaded and non-threaded) are stocked in over 500 sizes to give you low-cost protection for tubing, fittings, valves, hydraulic components and machined parts of every description. Your immediate requirements can be met promptly with "off-the-shelf" deliveries from a multi-million inventory.

MAIL THIS COUPON FOR FREE CAPLUG SAMPLE KIT WITH DESCRIPTIVE LITERATURE AND PRICES

CAPLUGS DIVISION, PROTECTIVE CLOSURES CO., INC.
2205-9 Elmwood Ave., Buffalo 23, N. Y.

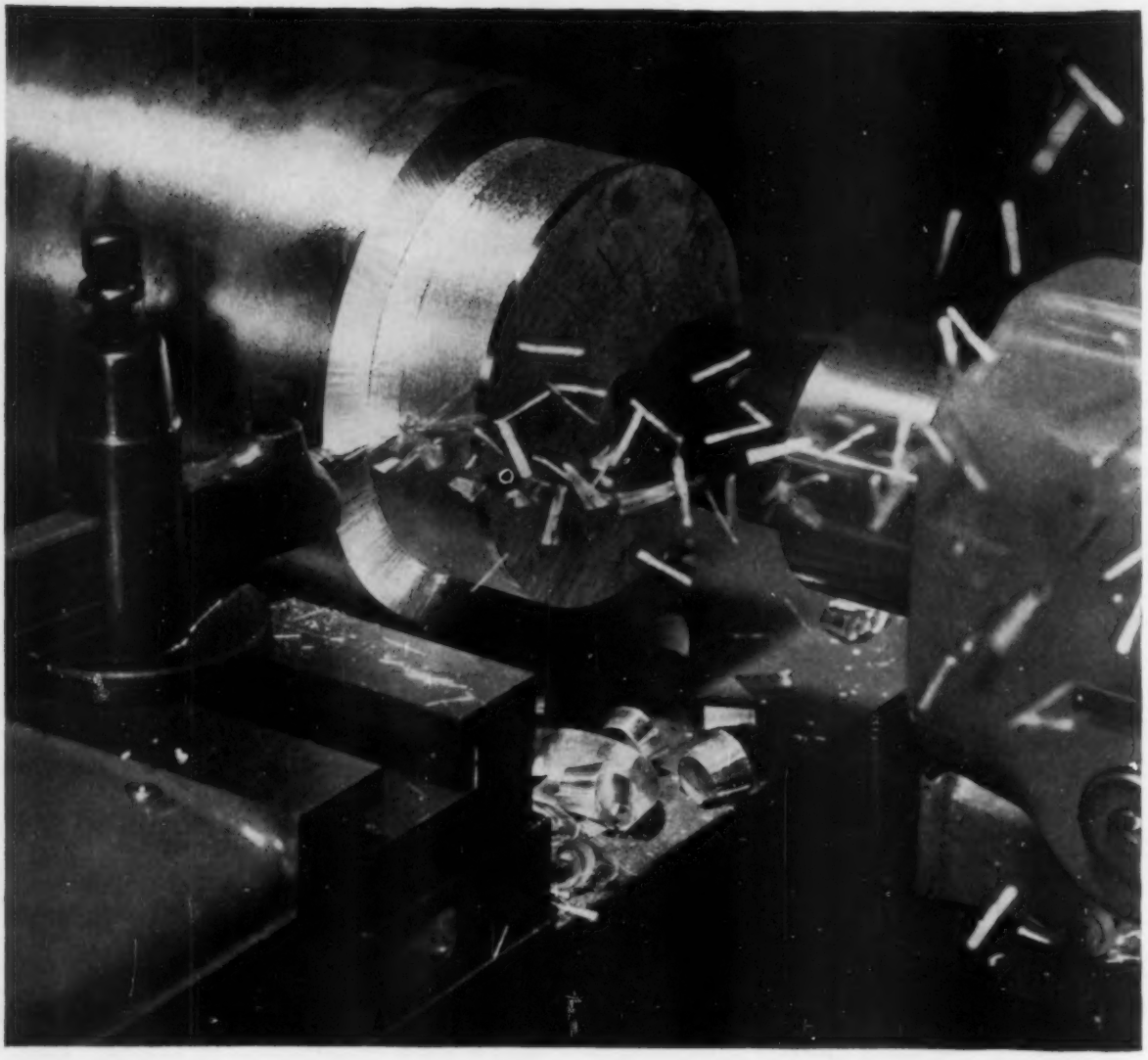
RUSH a free CaPlug sample kit, literature and prices to us, without obligation.

NAME _____ TITLE _____

FIRM _____

ADDRESS _____

CITY _____ ZONE _____ STATE _____



Speed! Of all structural metals, Magnesium costs less to machine

In the picture above, a lathe is making a roughing cut of 0.800" in an eight inch magnesium billet. The feed is 0.030 inches per revolution at a speed of 630 feet per minute. In finishing operations, cuts of 0.500" can be made with a feed of 0.003 ipr and a speed of 5,000 fpm.

That's real speed and efficiency—the kind you can always expect when you machine magnesium. This remarkable metal can be milled, drilled, sawed, reamed, bored, planed, tapped and threaded faster than any other structural metal!

Faster machining means easier machining and lower cost machining. It means more production per hour and per dollar, and longer tool life.

The following table shows how well magnesium compares to the others:

METAL	RELATIVE MACHINABILITY
magnesium	1.0
cast aluminum	1.8
brass	2.3
cast iron	3.5
rolled aluminum	5.0
mild steel	6.5

Let us give you more information about the machinability of magnesium. Contact the nearest Dow sales office or write to THE DOW CHEMICAL COMPANY, Magnesium Department, Midland, Michigan, Dept. MA 1404H.

YOU CAN DEPEND ON DOW

Completely Oil-Sealed!

A-B QUALITY

SEALED HEAD KEEPS OUT OIL, COOLANT, METAL CHIPS ...your guarantee of reliable limit switch operation!

With *completely sealed* operating heads, as well as sealed switch bodies, Allen-Bradley Bulletin 802T oiltight limit switches provide maximum reliability in limit switch operation for your modern, high speed production machines. The sealed head excludes oil, dirt, and metal chips from the operating mechanism ... the spring return, momentary contact operators cannot become sluggish and stick.

The maintenance free, double break, silver alloy contacts are sealed in the oiltight body. Interchangeable operating heads are available with various push rods and levers which can be mounted in any one of four positions. Oiltight transparent plastic covers, for inspecting contacts and wiring without removing the cover, are available for most units.

Here's a line of *quality* limit switches in which each type will provide millions of trouble free operations. Have your A-B control engineer acquaint you with this latest development—another advance in limit switch design.

802TC Side Push Rod Type

802TF Rod Type

802TA Roller Lever Type

802TB Top Push Rod Type with Plastic Window

802TAO Roller Lever Type for Cavity Mounting

802TG Adjustable Roller Lever Type

ALLEN-BRADLEY
MOTOR CONTROL

Allen-Bradley Co., 1316 S. Second St., Milwaukee 4, Wis.
In Canada: Allen-Bradley Canada Ltd., Galt, Ont.

9-57-MR

NOW... ALLEN-BRADLEY

PRECISION-TYPE LIMIT SWITCHES ARE ALSO OILTIGHT!

OILTIGHT HEAD — Newly designed head on push type seals out oil. Roller lever types have sealed operating shafts.

OILTIGHT BODY — Synthetic rubber gasket between housing and plate excludes oil and coolant from operating mechanism.

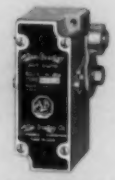
Allen-Bradley precision-type limit switches combine very close operating tolerances with such a sturdy construction that they can be used for any industrial application. Now this line of limit switches has been further improved by making them completely oiltight.

Especially designed for use where the motion to operate the limit switch is measured in thousandths of an inch, these Allen-Bradley limit switches can henceforth be employed in applications where oils, coolants, and dust are present.

Allen-Bradley Bulletin 802 oiltight precision limit switches have a positive snap action mechanism which prevents any possibility of a "dead center" . . . no matter how slowly the actuating force is applied. They are available in both the spring return and maintained contact construction. And all have maintenance free, double break, silver alloy contacts.

Specify these Allen-Bradley oiltight limit switches where "precision" operation is required and where dirt and oil could cause trouble.

Push rod type. Plastic cover, for inspection without removing cover, made for most units.



Roller lever type limit switch with lever on right side. Also available with lever on left side.

Roller lever precision-type limit switch with roller lever in front of the switch body.

ALLEN-BRADLEY
MOTOR CONTROL
QUALITY

Allen-Bradley Co.
1316 S. Second St., Milwaukee 4, Wis.
In Canada—
Allen-Bradley Canada Ltd., Galt, Ont.

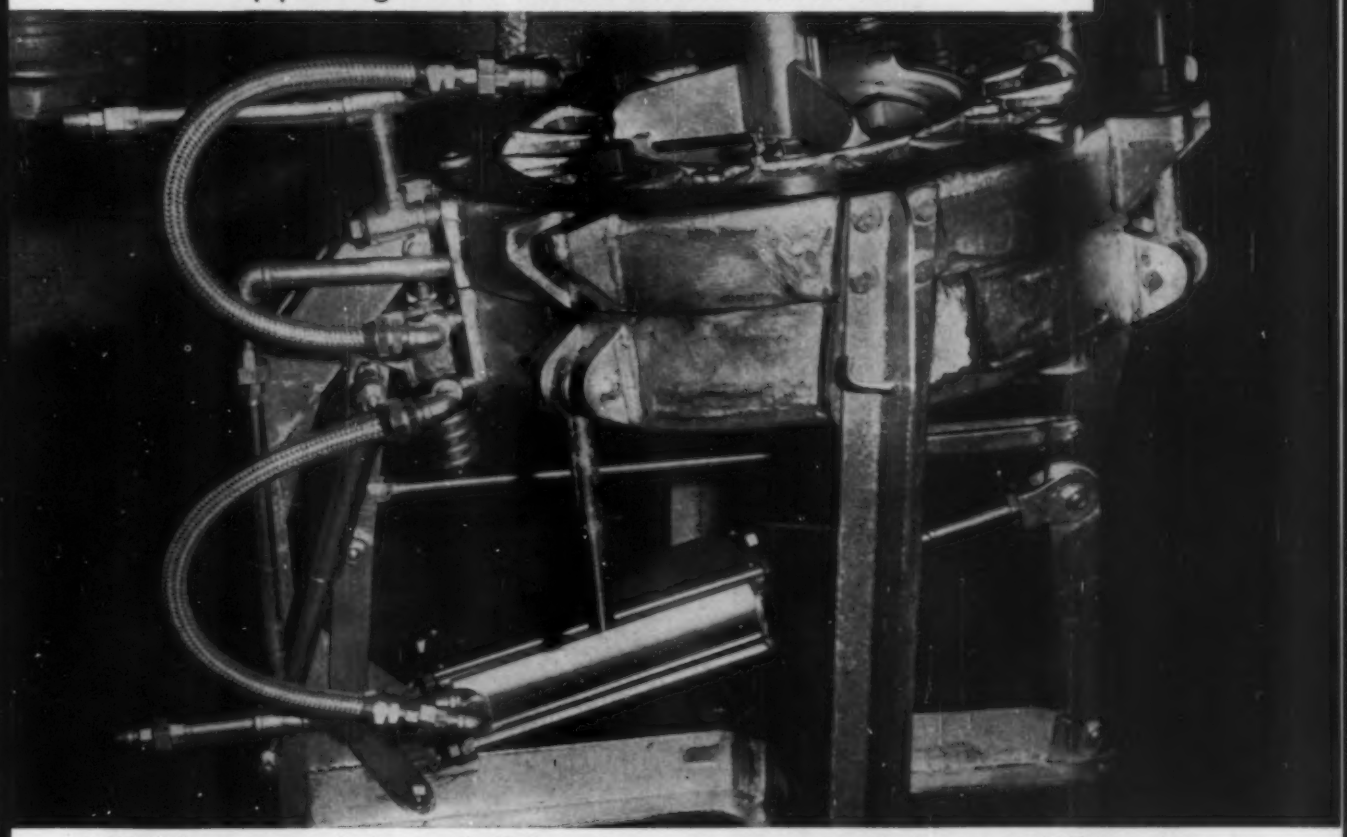
ALSO—GENERAL PURPOSE LIMIT SWITCHES

Bulletin 801 general purpose limit switches in standard or heavy duty ratings. Maintained or momentary contacts with slow or snap action. Silver alloy contacts used throughout this line.

9-57-MR

Where your problem is pipe that must flex

reduce pipe fatigue with American flexible metal hose



300°F, 50 lb. pressure is met by American Flexible Bronze Hose connecting moving steam chambers on Super Mold tire capping equipment.

"American flexible metal hose is tops for trouble-free service!" says C. R. Lohr of the Super Mold Corporation. Since 1940, American flexible metal hose has been conveying steam between moving parts on Super Mold tire capping equipment.

Whether frequency of flexure is a few times a week . . . or a thousand times an hour . . . you'll find American flexible metal hose is tight, safe, long lasting, easy to install. In field and laboratory tests American flexible metal hose has flexed millions of times without sign of failure.

Problems Solved by American Flexible Metal Hose

American flexible metal hose absorbs vibration and prevents its transmission to surrounding structures . . . absorbs expansion and contraction in lines due to temperature changes . . . facilitates installation especially in cramped spaces . . . solves the problem of misalignment.

Available in wide range of diameters in tough bronze, steel, super nickel, brass, stainless steel and other metals. American hose, complete with fittings, is made to your specifications and ready for immediate installation.

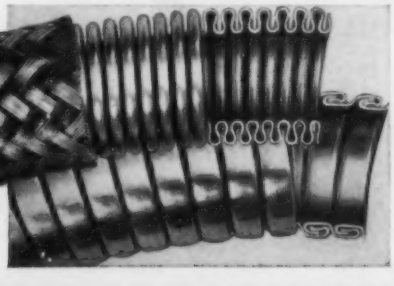
Consult your nearby American Metal Hose representative for engineering help when planning your next job. No obligation. See American Brass Company or Anaconda in your phone book — or write: American Metal Hose Division, American Brass Company, Waterbury 20, Conn. In Canada: The Canadian Fairbanks-Morse Co., Limited.

56181 Rev.

WHEREVER CONNECTORS MUST MOVE

AMERICAN FLEXIBLE METAL HOSE AND TUBING

AN **ANACONDA®** PRODUCT



BASIC TYPES

Seamless corrugated and Strip-wound. Both types available in a wide range of sizes and styles in any workable metal. Furnished with or without end fittings attached.

THE AMERICAN BRASS COMPANY
American Metal Hose Division, Waterbury 20, Conn.

Please send me a free copy of your new flexible metal hose and tubing catalog, G-560.

NAME & TITLE.....

ADDRESS.....

COMPANY.....

CITY, ZONE, STATE.....

You don't have to be over 21

to install and maintain

a Fenwal temperature indicating controller

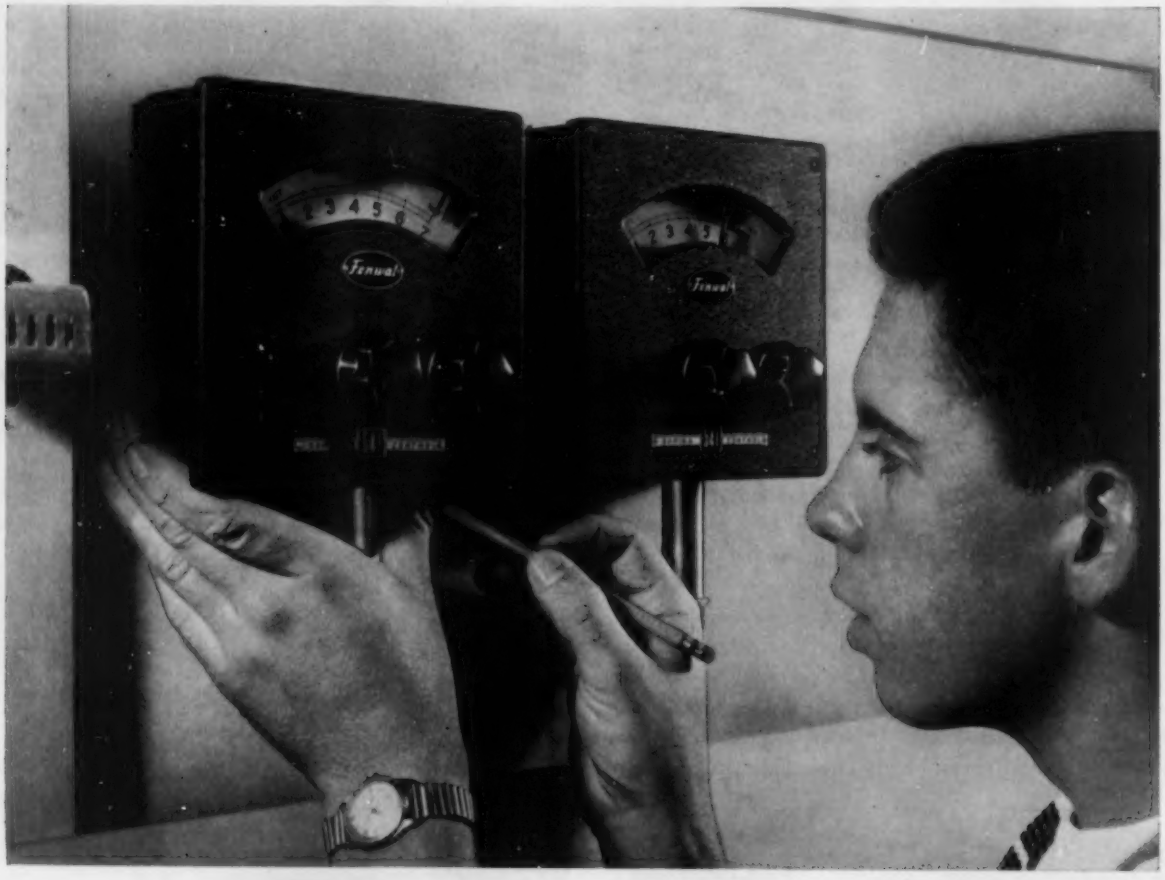
It really is a cinch for an untrained person to install and maintain Fenwal's 541 Temperature Indicator Controller. You don't even have to open the case to adjust it — even its snap switches can be easily replaced without disturbing the internal mechanism. *It's simple!*

In Fenwal's 541 all moving parts are in opposition — wear on one is automatically compensated for and the controller's high accuracy remains unchanged! *It's reliable!*

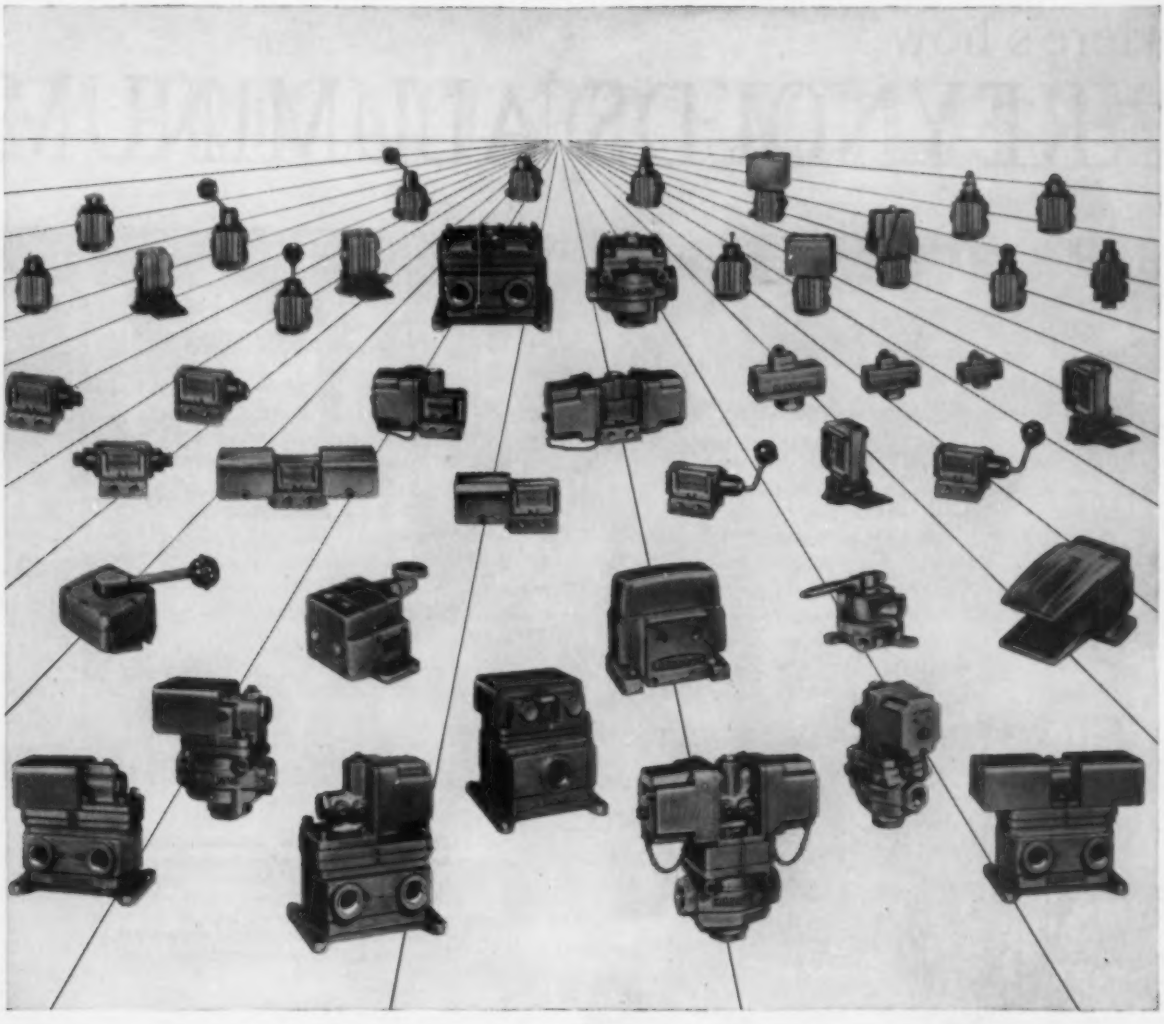
You can take your choice of temperature range, bulb styles, and one or two circuit controls, current ratings — even the color of the housing. There are literally hundreds of adaptations that can be made from stock! So you get a tailor-made, fit-to-order controller at a competitive price! *It's versatile!*

Drop us a line at Fenwal Incorporated, 211 Pleasant Street, Ashland, Mass. and we'll send you our catalog MC-139 or our sales engineer, whichever you want.

This is our dual circuit model (we've got hundreds of others) which has two snap switches, each with a set point indicator, that actuates two circuits at pre-set temperatures. Housing in all Fenwal 541's meet NEMA and JIC specifications.



Fenwal CONTROLS TEMPERATURE . . . PRECISELY



These valves like tough jobs

Discriminating engineers are finding that out. More and more of them are specifying Hannifin valves for every kind of directional air control—including the really tough jobs.

There are plenty of reasons why: Inspired simplicity of design. Fewer parts—and *those* easily and quickly replaceable. Ability to serve a wide range of applications with fewer valve models. And—above all—fast, smooth operation.

Your Hannifin man will gladly give you the whole story. We'll tell you where to get in touch with him—after you examine the big Hannifin catalog.

AIR CONTROL

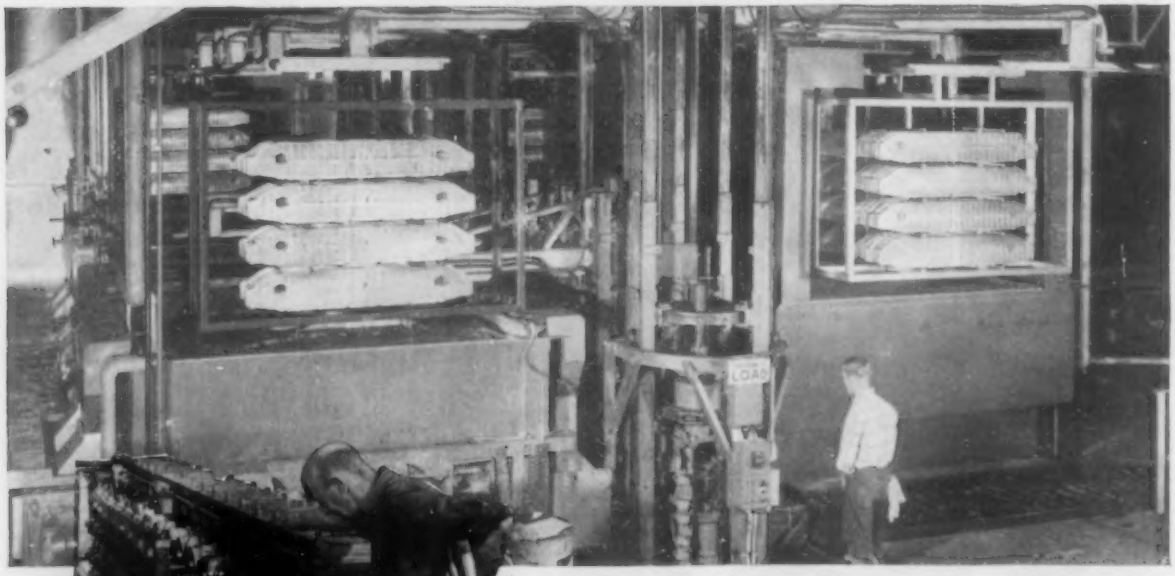
HANNIFIN

VALVES

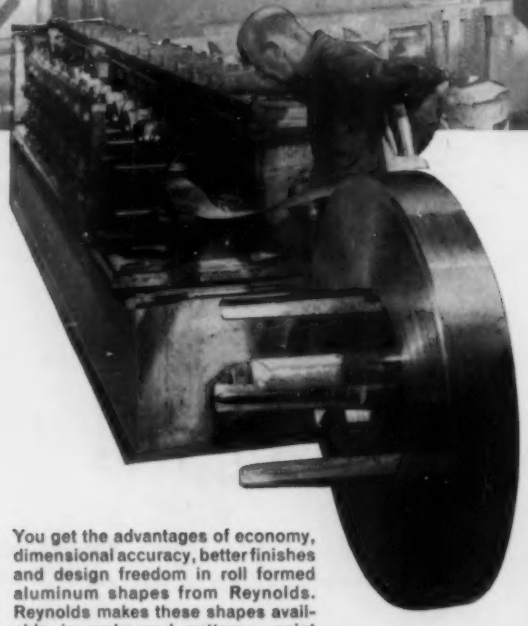
***For this complete catalog** showing all the Hannifin directional air control valves, write to Hannifin Corporation, 525 South Wolf Road, Des Plaines, Illinois.*

Here's how

REYNOLDS ALUMINUM



This new Reynolds automatic aluminum finishing system can finish mixed sizes and types of parts and chemically brighten or anodize them in different colors—and can handle several different jobs at the same time. An automatic coding system establishes the individual finishing specifications for each job.



You get the advantages of economy, dimensional accuracy, better finishes and design freedom in roll formed aluminum shapes from Reynolds. Reynolds makes these shapes available in embossed patterns, paint finishes and plain or color anodized finishes.

Brazing, (above) and welding, (left) are daily fabricating operations at Reynolds. Crater-free fusion welding, inert-gas-shielded metal arc welding and other types of welding are handled quickly, efficiently at Reynolds.

See "CIRCUS BOY", Sundays, NBC-TV.
Watch for Reynolds on "DISNEYLAND", ABC-TV.

FABRICATING FACILITIES

assure efficient, economical production of the products you design

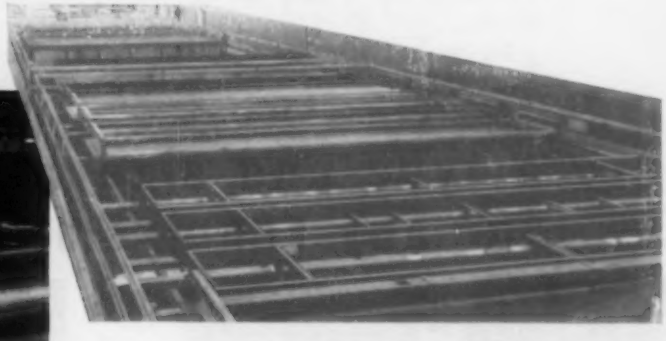
If the products (or parts for products) you are designing call for aluminum, Reynolds fabricating and finishing facilities may be the answer to low cost, fast, quality production. Here's why:

Reynolds has the right type of *equipment* for fabricating and finishing aluminum parts. There are good examples of some of this modern equipment on these pages. Reynolds has the *experience* . . . has the technological know-how in producing and fabricating aluminum. Reynolds guarantees *quality* . . . controls it from mine to finished part.

These advantages of facilities, experience and quality control add up to savings of many kinds. Savings in capital outlay for equipment and added plant capacity. Released floor space. Reduced raw material inventory. Elimination of scrap loss, scrap handling expense and reject costs. And this combination of advantages points the way to increased flexibility of design with the assurance of quality production of the products you design.

Send for Reynolds "Complete Facilities" brochure. And for the assistance of Reynolds Styling and Engineering Service and for details on Reynolds fabricating and finishing facilities, contact your nearest Reynolds Office or write *Reynolds Aluminum Fabricating Service, 2051 So. Ninth St., Louisville, Ky.*

Over 200 pieces of major fabricating equipment are available in just two Reynolds plants alone. Above is part of a battery of Reynolds new high speed coil fed presses.



This new Reynolds half-block long anodizing installation can handle parts up to 24' long, 12' high and 4' wide.

Scratch-brushing, satin finishing, embossing and other mechanical finishes are available from Reynolds. Here is part of a battery of Reynolds new high speed buffing equipment.

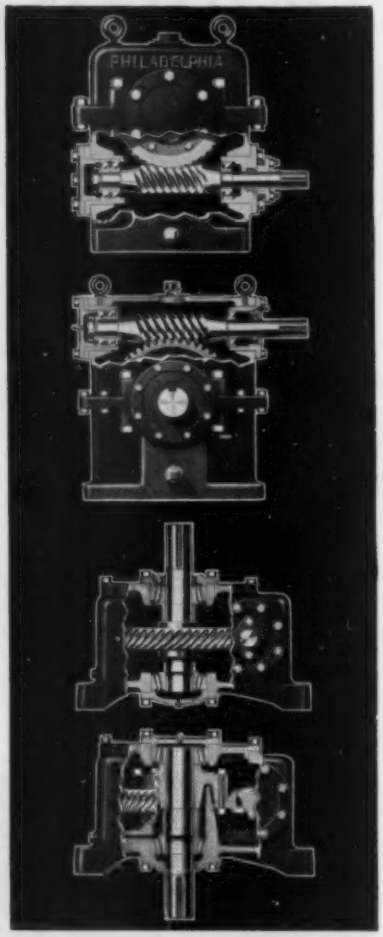
The Finest Products Made with Aluminum are made with REYNOLDS ALUMINUM

REYNOLDS ALUMINUM Fabricating Service

BLANKING • EMBOSSING • STAMPING • DRAWING
RIVETING • ROLL SHAPING • TUBE BENDING
FORMING • WELDING • BRAZING • FINISHING

Quality is *inherent*, Service and Long Life *proven*...

Philadelphia WORM GEAR REDUCERS



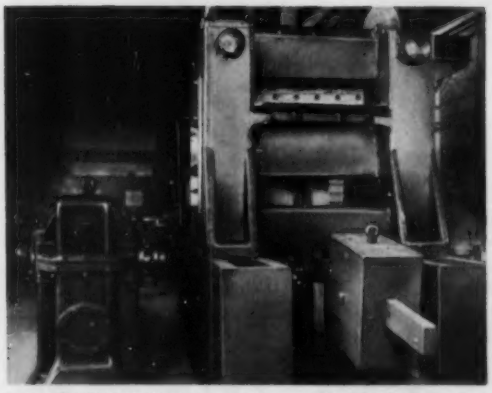
Whether you desire just worm and worm gear sets, or complete self-contained Worm Gear Speed Reducers — Phillie Gear is capable of meeting your most exacting requirements.

Philadelphia Worm Reducers are available in single or double reductions in horizontal right angle drive types, with the output shaft above or below the worm shaft — and in single or double vertical types, with output shaft extending up or down. Standard reductions in the single type are up to 90 to 1, and the double reduction types from 102 to 1, to 6300 to 1.

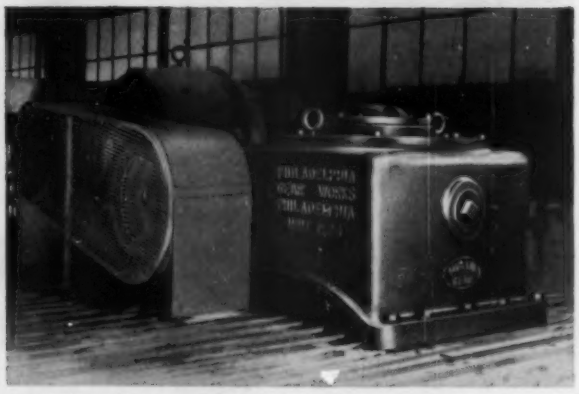
All sizes and types of Philadelphia Worm Reducers provide efficient, smooth and dependable power transmission under the most rigorous and severe operating service — Thousands are in daily use in industry throughout the World.

For detailed information, write for Catalog WG-562, and please use your Business Letterhead when requesting your copy.

a type and size for any requirement



Type AT Philadelphia Worm Reducer driving 44" Up-cut Hot Shear.



Double Reduction type DVT Philadelphia Worm Gear Reducer on special down-shaft application.

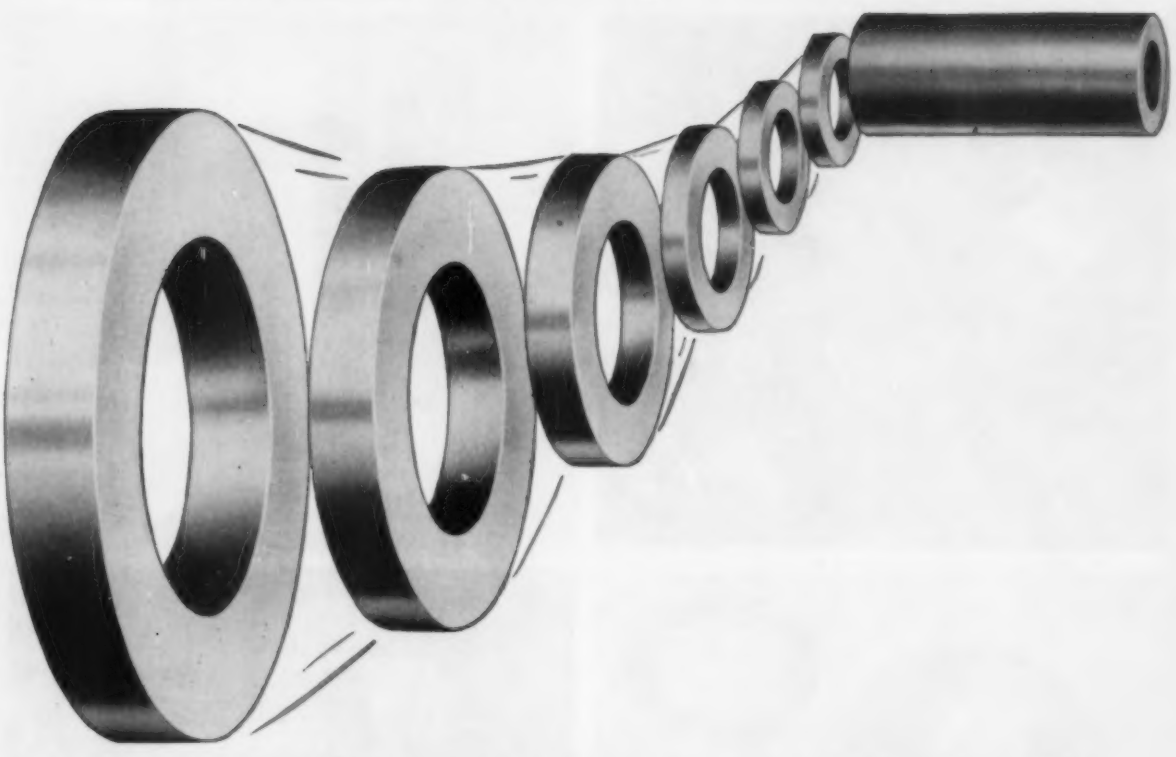
phillie gear®

PHILADELPHIA GEAR WORKS, INC.
ERIE AVE. & G STREET. PHILADELPHIA 34. PENNA.
Offices in all Principal Cities

INDUSTRIAL GEARS & SPEED REDUCERS • LIMITORQUE VALVE CONTROLS • FLUID MIXERS • FLEXIBLE COUPLINGS

Limitorque Corporation • Philadelphia

How to add machining capacity without adding machines



. . . and save money on your steel!

ARE you making hollow parts, or boring out solid bar stock? Timken® seamless steel tubing can eliminate that unnecessary and costly boring operation—because Timken seamless steel tubing comes with *the hole already there.*

By cutting out this needless operation, you free screw machine stations for other jobs. You get increased machining capacity without adding machines. More than that, you pay only for the steel you use—without wasting solid bar stock centers. And of course you speed up your hollow part operation by starting with Timken seamless steel tubing; *finish* boring can become your first production step.

Timken seamless steel tubing is made by a piercing process which is basically a forging operation. So you get fine forged quality: uniform spiral grain flow for greater strength, and refined grain structure. This quality is maintained from heat to heat, tube to tube and order to order. The Timken seamless steel tubing recommended by our engineers as *your* most economical tube size will be guaranteed to clean up to your finished dimensions.

The Timken Roller Bearing Company, Steel and Tube Division, Canton 6, Ohio. Cable address: "TIMROSCO".

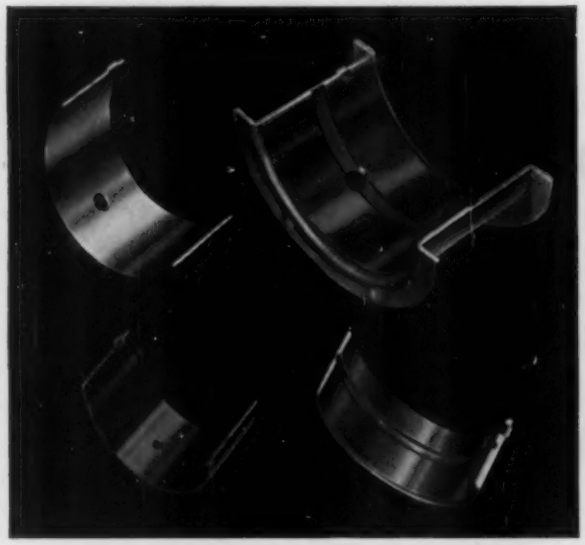
TIMKEN *Fine Alloy* **STEEL**

TRADE-MARK REG. U.S. PAT. OFF.

SPECIALISTS IN FINE ALLOY STEELS, GRAPHITIC TOOL STEELS AND SEAMLESS STEEL TUBING

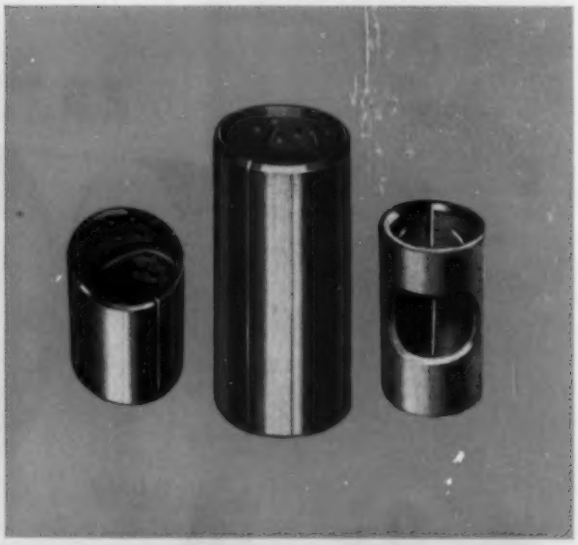
Three alloy linings meet 95% of engine bearing needs

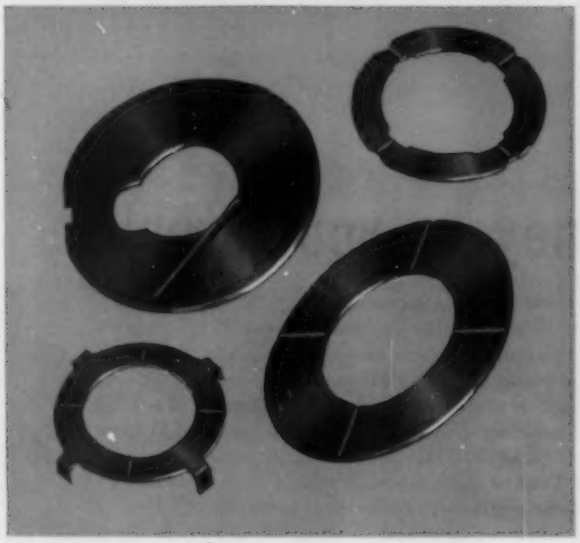
Experience shows a steel back lined with tin- or lead-base babbitt or copper-alloy meets performance requirements.



Bimetal and Plain Bushings offer substantial economies

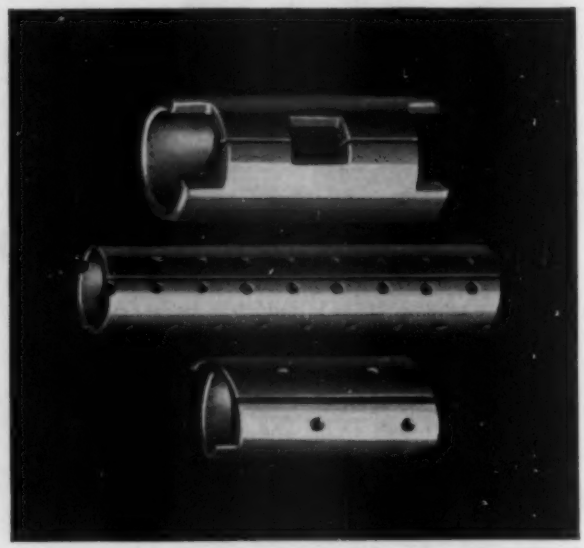
Rolled split plain bronze, steel or aluminum; or steel lined with bronze, babbitt or copper-alloy. Many design variations possible, plus volume production economies.





Precision Thrust Washers in Bronze or Bronze on Steel

Cold rolled for heavy duty. Steel faced with copper-alloy on one or *both* faces. Nibs, lugs, coined oil grooves. Flat, spherical or special shapes. From 1″ to 6″ O.D.



Economical Spacer Tubes for Hundreds of Applications

Money-saving substitute for iron pipe, tubing or machined parts. Delivered ready for assembly, to exact dimensions—or can be brazed to other components.

FEDERAL Mogul SINCE 1899

FEDERAL-MOGUL DIVISION

FEDERAL-MOGUL-BOWER BEARINGS, INC., 11043 SHOEMAKER, DETROIT 13, MICHIGAN

RESEARCH • DESIGN • METALLURGY • PRECISION MANUFACTURING

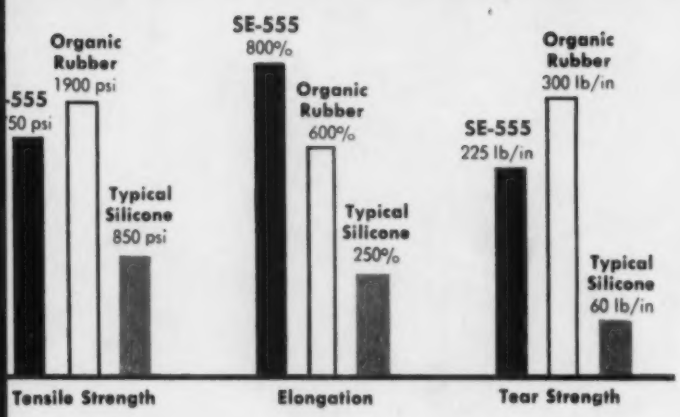
HOW TO SOLVE
PRODUCT DESIGN PROBLEMS WITH

SILICONE IDEAS

HIGH STRENGTH RUBBER PARTS

HIGH TEMPERATURE WIRE INSULATION

HIGH TEMPERATURE PAINTS

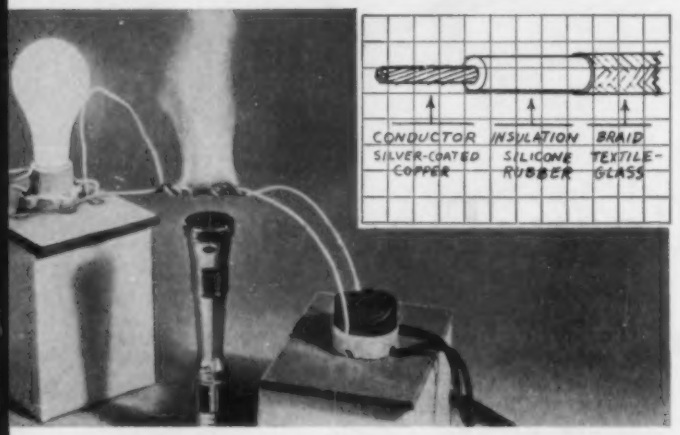


Problem: *Organic rubber parts failing because of temperature extremes and ozone. High tear and tensile strength cannot be sacrificed.*

Solution: Replace with SE-555—silicone rubber with tear and tensile strength comparable to organic rubber.

SE-555 is a new silicone rubber with tear and tensile strength double that of ordinary silicone rubber (see comparative typical values at left). Whenever maximum resistance to weather and temperature extremes (minus 150°F to 500°F) is required, combined with high tear and tensile strength, specify SE-555. This is the only material available to rubber fabricators that meets AMS 3345 requirements for tear and tensile strength, elongation, heat resistance, compression set and low temperature flexibility. SE-555 can be fabricated in practically any color, including white.

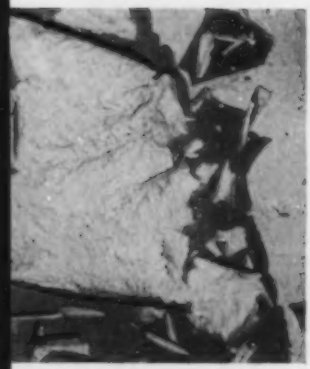
You can order high strength silicone rubber parts immediately because SE-555 is available from stock for shipment to your fabricator. For more information and a list of qualified fabricators, mail the coupon below.



Problem: *Find a wire insulation to withstand extreme conditions of temperature, moisture and ozone.*

Solution: Wire insulated with G-E silicone rubber.

Exposed to an 1800°F flame for hours, G-E silicone rubber insulation forms a non-conducting ash which still insulates. No toxic fumes are released, nor will it shrink and expose the conductor, as the laboratory demonstration on the left shows. Silicone rubber has superior dielectric strength at high temperatures and keeps it for years. It has unparalleled ozone resistance, stays flexible down to minus 75°F or lower. Use silicone rubber insulated wire wherever temperatures are extreme, and where an extra safety margin is needed. Examples: aircraft wire, Class B and H motor and apparatus lead wire, electronic hook-up wire and control cable. Want more information? Send in coupon below.



on steel coated with an alkyd aluminish, subjected to 1000°F for 2 hours.

Carbon steel coated with silicone aluminum finish, subjected to 1000°F for 24 hours.

Problem: *Extend the life and appearance of metal surfaces designed for high temperature operation.*

Solution: Special paints made with G-E silicones.

Silicone based paints are finding increased application as corrosion-resistant or appearance-preservation coatings for many metals exposed to continuous temperatures as high as 1000°F. For instance, special aluminum-silicone paints often make it possible to use mild steel instead of stainless steel in industrial applications. High gloss silicone paints have proved to be amazingly durable finishes for heaters, appliances, etc. Gloss and color are retained up to 440°F, and the finish resists marring, scratching and chemical attack more than ordinary paints. Check into the performance advantages of high temperature silicone paints. Special paint formulations have been developed by leading paint manufacturers for specific temperature ranges and applications. For more data, fill in the coupon below.

Write for more information...

GENERAL ELECTRIC

Silicone Products Department, Waterford, New York

Section D6A9, Silicone Products Dept.
General Electric Company, Waterford, N. Y.

Please send me application data and names of suppliers of:

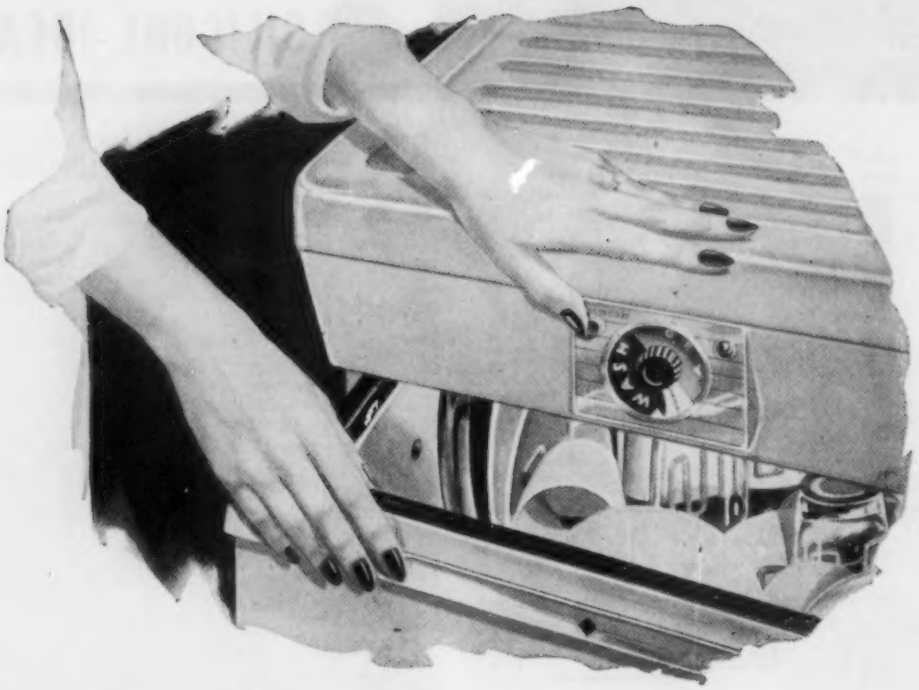
☐ Silicone rubber mechanical goods
☐ Silicone rubber insulated wire ☐ Silicone based paints

Name_____ **Title**_____

Company_____

Address_____

City_____ **Zone**_____ **State**_____



Defeating Drudgery– Task for Mallory Timers

Take the burden of tedious, drudging work out of human hands and make operation automatic—and you have a market ready to buy. This concept has proved itself in automatic home laundries, clothes driers, vending machines . . . and offers interesting possibilities in other types of products for factory and farm.

What makes millions of these self-operating devices and appliances *automatic* is a Mallory timer switch! Designed for ruggedness and versatility, Mallory timers are manufactured to high standards of precision at economical cost, for leading appliance makers.

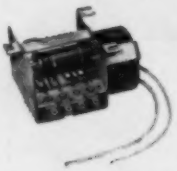
When you are looking for ways to make your new products automatic, you may find that Mallory already has the answer to your timer switch problem. In addition to the Mallory switch that makes a dishwasher automatic, Mallory has other timer switch models—each capable of many variations in cycle time, current rating and other characteristics, cover an almost endless combination of uses. Two of these are illustrated:

For a consultation on your specific automation problem, write or call Mallory today.

Serving Industry with These Products:

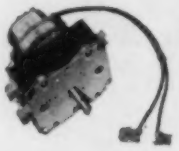
Electromechanical—Resistors • Switches • Television Tuners • Vibrators
Electrochemical—Capacitors • Mercury and Zinc-Carbon Batteries
Metallurgical—Contacts • Special Metals • Welding Materials

For cycles from 1 second to several hours



the new Mallory interval timer controls up to 6 circuits to high precision. Timed portion of the cycle can be adjustable. Motor reset gives positive, spring-less return to original start position. Nominal rating: 10 amperes at 125 volts and 5 amperes at 250 volts; other ratings are possible.

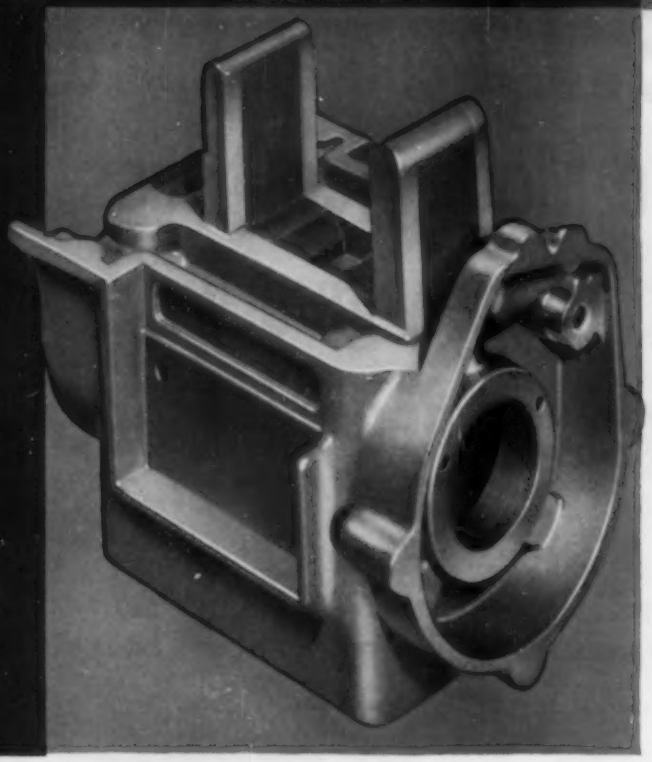
For heavy duty . . .



another Mallory timer controls two 25-ampere circuits. Self-cleaning spring contact assembly has long life, fast opening; ends danger of sticking of contacts. Many variations in motor mounting, built-in bussing and terminal arrangement are available.

Expect more . . . Get more from

P. R. MALLORY & CO. Inc.
MALLORY
P. R. MALLORY & CO. Inc., INDIANAPOLIS 6, INDIANA



Problem: To produce a rugged, one-piece, weatherproof magneto frame for International Harvester farm tractors. Five separate magneto parts must be incorporated into the body of the casting, and accurately positioned to meet exacting tolerances of the final assembly. Must be designed for fast, economical production.

Solution: Working closely with IHC, Stewart Die Casting engineers developed a "slide die" consisting of an elaborate system of cores, slides and positioners. This intricate arrangement holds the two magnetic field pieces, the two magnetic pole pieces, and the bearing race in exact position while the metal is injected around them in the die. The result was a precision casting that can be produced economically with a minimum of rejects, and give dependable performance under all conditions.

Stewart found the solution and made delivery on time!

This is just one of many complicated die castings that Stewart has developed promptly . . . and produced in quantity *at low cost.*

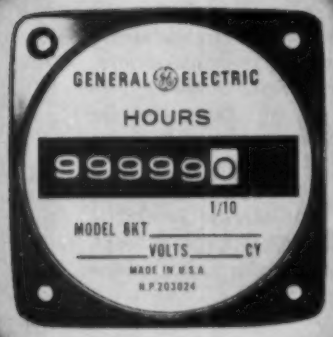
Nearly half a century of experience, plus unexcelled production facilities, enables Stewart to offer fast, practical solutions to any die casting problem.

Whatever type of die casting you need— large or small, simple or intricate — you can count on Stewart for a quality job . . . delivered on schedule!

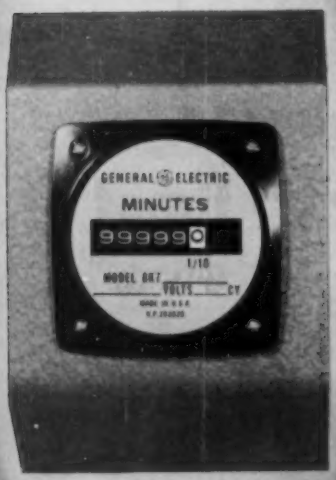
Stewart DIE CASTING
Division of STEWART-WARNER CORPORATION
Chicago, Illinois: 4535 Fullerton Avenue • Bridgeport, Connecticut: 275 Warren Street

46 YEARS OF SERVICE TO INDUSTRY

Round model for panel mounting.



Square model for panel mounting.



Portable model for laboratories.

Conduit case for easy installation.

NEW General Electric Time Meters cost less, read easier, give wider range of measurement

ALL DIGITS 2½ TIMES LARGER—NEW, EXTRA DIGIT GIVES WIDER RANGE FROM 0 TO 99999.9 HOURS OR MINUTES

OLD
(Life Size)

NEW
(Life Size)

At a new, low cost, General Electric now offers you a complete line of time meters for measuring operating time of every type of electrical equipment.

Available in 2½ and 3½ inch sizes these new General Electric Time Meters offer you these important benefits:

- **DUST-PROOF PROTECTION . . .** due to totally enclosed construction. Sealed models also available to military specifications.
- **RESET MODEL . . .** conveniently located reset knob available (optional) on all General Electric Time Meters except sealed models.
- **INCREASED OPERATING TEMPERATURE RANGE FROM**—67F to 150F . . . means more flexible application and longer meter life.

3 WAYS YOU BENEFIT WITH GENERAL ELECTRIC TIME METERS:

LOWER COST, BETTER PLANNED MAINTENANCE . . . because you can measure the operating time of your equipment, thus allowing you to apply pre-planned productive maintenance.

LESS DOWNTIME, FEWER PRODUCTION LOSSES . . . because you can measure the total operating life of your equipment, and thus replace it on a scheduled basis before it breaks down unexpectedly.

BETTER UTILIZATION OF MANPOWER AND MACHINES . . . because General Electric Time Meters measure the shutdown time of your equipment, allowing efficient scheduling of employee and machine work assignments.

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To change the style—change the steel to Sharonart Literature and sample kits upon request. **Sharonart*** is a trademark of the Sharon Steel Corporation.

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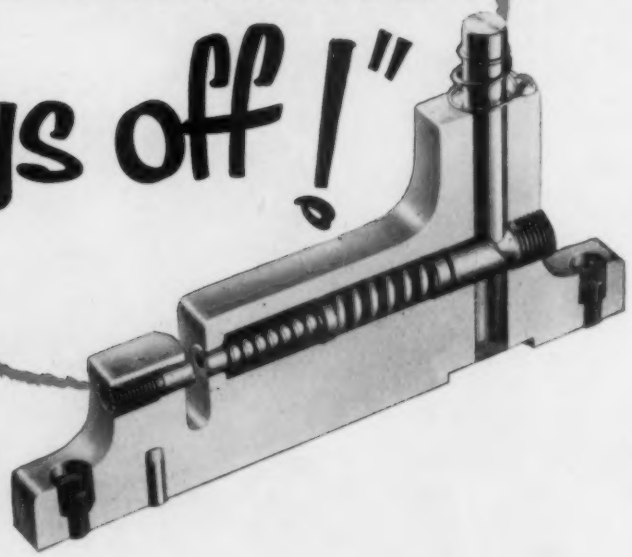
easy installation.

"WALES HORIZONTAL HOLE PUNCHING pays off!"



Punching holes in any kind of flange, angle, channel or shape is usually a costly operation requiring custom dies, but not with WALES Standard H Tooling. This exclusive self-contained tooling equipment, with interchangeable punch, die and stripping mechanism makes possible fast, economical hole punching. WALES H Tooling insures FAST set-up with automatic alignment and the same equipment may be used over and over again in any number of patterns. Bench assembly virtually eliminates press down time. H Tooling is available to meet your every production requirement.

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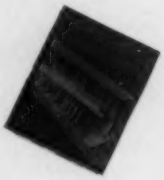

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FROM BRUNING – Your One Convenient Source for All Drafting Needs...

5 Wonderful Time-and-Work Savers!

The right tool or material for the job, whether it is a large or small item, means a lot in drafting! That's why the outstanding drafting aids featured here are important to you. That's why they are important members of Bruning's complete quality line. Try them: you will be mighty pleased at how fast the savings of time and labor mount up!

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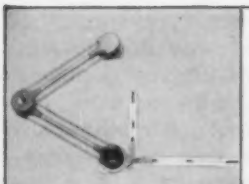
Make faster, neater, safer erasures with the only electric eraser that gives you all these *plus* advantages: a light, die-cast body that's contour-shaped for comfort (no sharp edges, no finger-cramping design); a quick, snap-action chuck that's easy to use (no bothersome, time-consuming twisting or turning necessary); first-quality sealed bearings that practically eliminate friction heat and wear... assuring you of longer, cooler, trouble-free performance that's unsurpassed. Hollow-shaft design—developed and perfected by Bruning—permits use of extra-long, 7-inch erasers for greater safety, speed, convenience, and economy. Five grades of erasers available for every erasing need.



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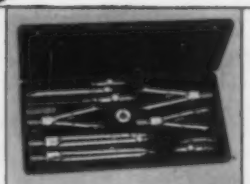

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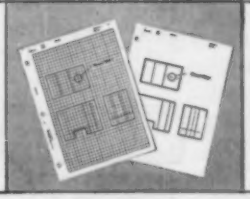

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Please send me information on these Time-and-Work Savers:

☐ Electric Erasing Machine ☐ "Varsity" Drafter ☐ "Wild" Instruments
☐ "Visi-Vel" Tracing Paper ☐ Cross Section Pad

Name_____ Title_____

Company_____

Address_____

City_____ County_____ State_____

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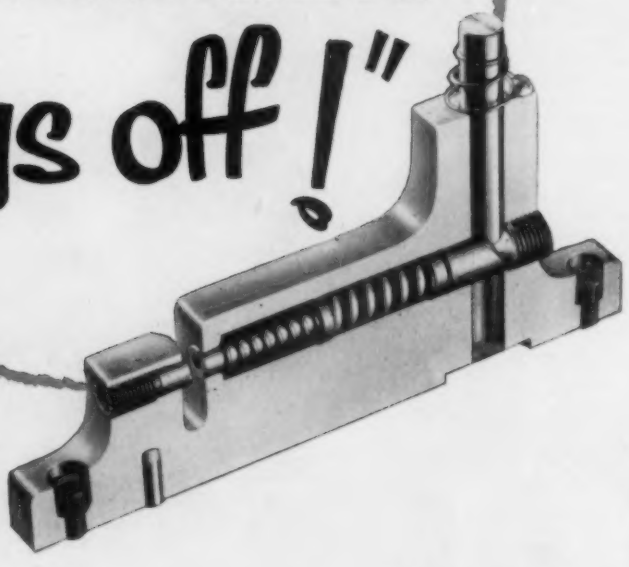

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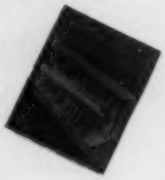

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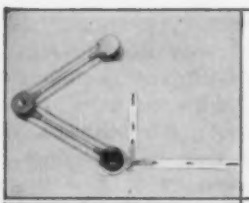

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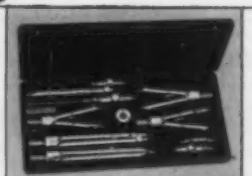

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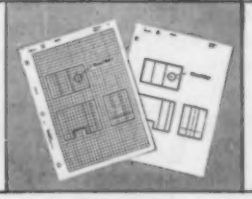

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Name_____ Title_____

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City_____ County_____ State_____

PREVIOUS PROCEDURE

1 Drill bolt holes in "clip angles."

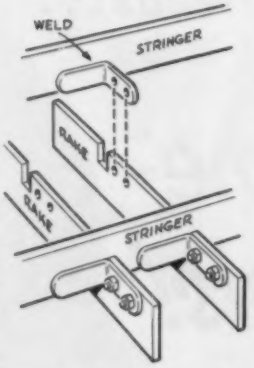
2 Weld clips to stringer.

3 Drill holes in rake blades.

4 Mill stringer slots in rake blades.

5 Bolt rakes to clip angles.

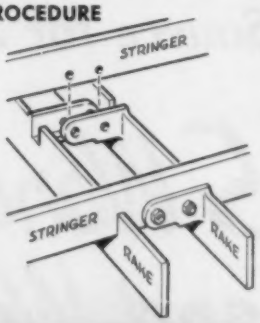
REPEAT FOR EACH BLADE



PRESENT PROCEDURE

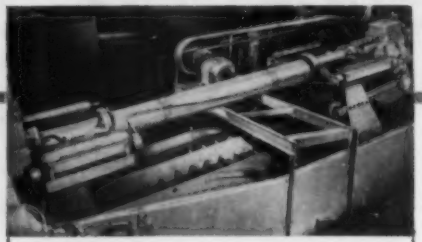
1 Drill bolt holes in stringer.

2 Bolt one-piece castings (complete with holes, slots, and flanges) IN RIGHT- AND LEFT-HAND PAIRS, to stringers.

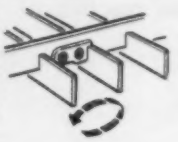


Use of Cooper Alloy close-tolerance shell casting eliminates 3 out of 5 machining operations for Dorr-Oliver rake classifier blades, showing

How to Cut Fabrication Costs with Close-Tolerance Stainless Castings



Type H rake classifier made by Dorr-Oliver Inc., of Stamford, Conn., separates solids in liquid-solid mixtures into two fractions according to particle size. Fine materials overflow with liquid at lower end of inclined tank; larger particles settle to tank bottom, are continuously raked up inclined slope and discharged "over top" Rake blades move in oval track due to motion of rocker head, must be precisely aligned to move settled material up to next rake without either scraping or undue clearance.



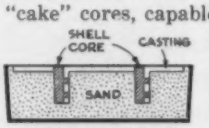
Previous method of attachment of rakes to stringers was by "clip angles" welded to stringers, drilled and bolted to simple flat blades themselves drilled and slotted as shown. Construction was expensive, and often unsatisfactory, in that heat of welding tended to put rakes out of alignment.

In redesigning, Dorr-Oliver decided to eliminate the clip angle as a separate third piece by incorporating it into the blade castings. Original conception was to cast rough slots and holes, then mill and drill them to dimensions. Cooper Alloy, after study of the piece, determined that with close-tolerance plastic shell cores, both bolt holes and stringer slots could be cast directly in the rake blade, without need of further machining. Also, that by using right- and left-hand patterns of rake flanges, *two* rake blades could be bolted to stringers with one set of bolts.

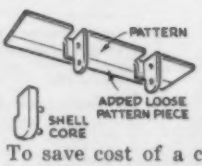
Casting requirements stringent

- Bolted face of each of the upright flanges required a smooth finish (250 A.S.A. Standard).
- $1\frac{1}{16}$" cored holes had to be smooth, accurate to ±.010", and precisely positioned for proper fitting of parts.
- Stringer slots had to be precisely positioned, accurate in dimensions to ±.025".
- Multiplicity of patterns for different widths of rake blades had to be reduced, for economy.

Casting solutions For the critical flange faces and bolt holes, shell "cake" cores, capable of holding precise dimensions down to ±.010", were prepared. They were inserted and became an integral part of the green-sand molds that formed the less critical outer blade areas.



CUTAWAY ELEVATION: ENTIRE PIECE IN DRAG.



To save cost of a complete new pattern for each rake size, all sizes of rake were designed to have the same blade thickness and flange dimensions. Patterns were then made of the narrowest-width blade in each series, loose pattern pieces being added to increase blade width of the larger rake sizes.

Results –"These rake blades", says Dorr-Oliver, "were used directly as cast, with no additional machining of any kind. Dimensions were precise, surfaces smooth, and finished alignment better than with previous 3-piece welded assembly. New procedure saves time and handling, and has reduced our manufacturing costs on this piece considerably."

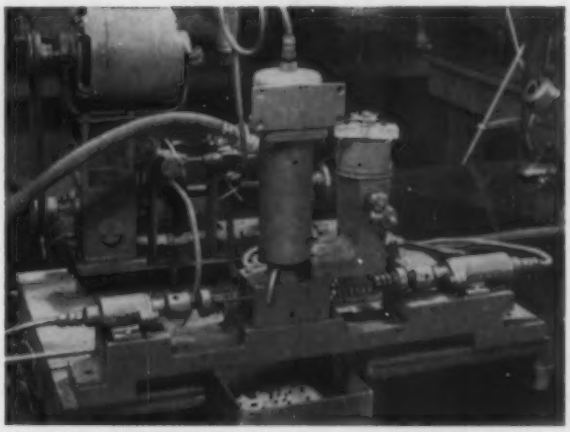
Such economy possibilities are available in almost any shape, no matter how simple, or how "cut-and-dried". Cooper Alloy has specialized for 35 years in achieving such uncommon results in close-tolerance stainless steel castings, and can do the same for you.

To check on it, why not take advantage of our Foundry Engrg. Service? Just send us (without obligation) a blueprint or outline of your problem part, for cost analysis, to: Foundry Products Division, COOPER ALLOY CORPORATION, Hillside, N. J.

***Progress** in designing air systems:*

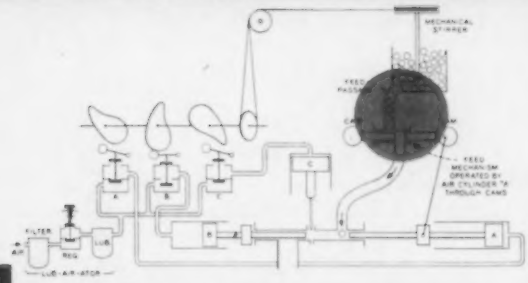
Here's another automating idea: Schrader Air Products in a multi-step punching system

PROBLEM: To pierce tiny balls of lead shot, fast, accurately, and economically.



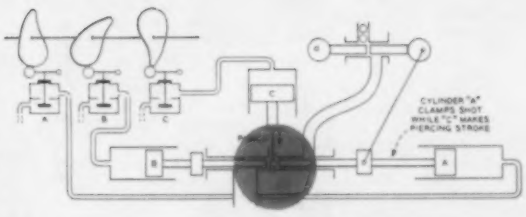
Schrader Products successfully performing at prominent Western plant—feeding, shot-piercing, ejecting—all automatically with air.

SOLUTION: Schrader Air Products designed into a system for automatic operation.



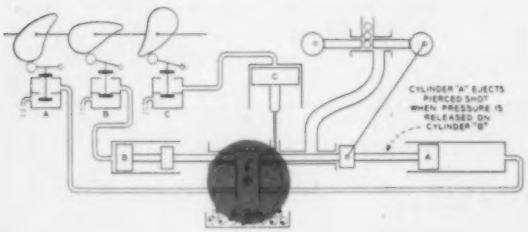
1

FEED: Performance of the cylinders in this system is controlled by cam-actuated Schrader valves. Cylinder A controls split-cam feed; allows the shot to be fed into the machine one at a time.



2

PIERCE: The shot is pushed forward and clamped at the piercing station by cylinder A and cylinder B. Cylinder C pierces the shot.



3

EJECT: Cylinder B returns to its initial position. Cylinder A completes its forward stroke, ejecting the pierced shot. And cycle starts again.

Air's benefits apply in almost any operation you can name: stamping, forming, programming, squeezing or measuring. And the advantages are more important today than ever: speed, accuracy, safety, simplicity, versatility, and—amazing economy. Schrader components are a natural for the designer because they comprise the only complete line of air products to select from. They can be used singly or in combination to perform jobs of amazing variety and complexity. When you design, think of air, and make use of Schrader's engineering facilities to help you specify the right products for your idea. Mail the coupon today.

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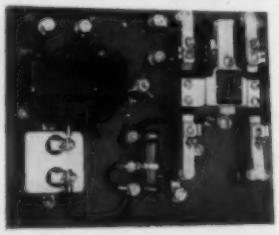
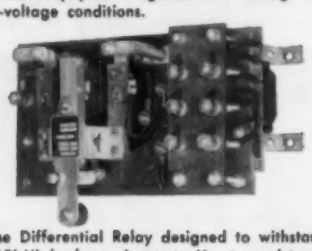
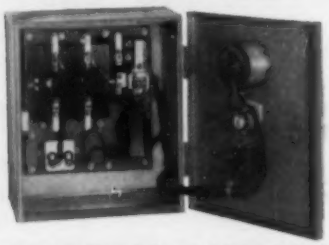
ASCO close differential relays respond crisply to 2% voltage or current variations... with no chattering on pickup or dropout.



Voltage Type Close Differential Relay protects electrical equipment against low voltage or over-voltage conditions.



Close Differential Relay designed to withstand NAVY Hi-shock requirements. Has tapped transformer making the relay suitable for a series of different pickup and dropout voltages.



Current type Close Differential Relay Panel for process control. (Relay operates as a function of motor load current.) Has adjustable pickup and dropout control. Panel has been used successfully for controlling cotton baling equipment.

ASCO Close Differential Relays (available either A-C or D-C) have been developed to meet the demand for a unit having the ruggedness of a power relay yet retaining the sensitivity of a primary control relay.

FEATURES

• Positive action on make or break, with no tendency to creep on opening or closing • 2% Sensitivity • Wide Variety of Applications • Available in Various Pole Combinations Up To 2 Normally Open and 2 Normally Closed Poles • Continuously Adjustable Pickup, or Variable Pickup By Tap Changing is Available • Continuous Dropout Adjustment is Standard.

MODIFIED ARRANGEMENTS

• High Shock Design • Variable Pickup • Frequency Response • Delayed Action • D-C Relays Also Available.

APPLICATIONS

As Voltage Relays they are extensively used in power and lighting systems to protect electrical equipment against low voltage or over-voltage conditions. For example... they permit detection where motor feedback conditions would not permit detection by ordinary potential relays. These relays are regularly furnished with ASCO Transfer Switches to provide voltage supervision of single phase and polyphase systems.

As Current Relays they have found extensive application as off-peak load relays to automatically disconnect selected loads, preventing system loading beyond set values. Close differential detection makes ASCO Close Differential Relays ideal for process control by motor current measurements.

Close Differential Relays are only part of the complete line of Relays offered by ASCO. ASCO Catalog 57-S4 lists:

• MAGNETICALLY HELD RELAYS
AC or DC ... Normally Open ... Normally Closed ... Double Throw
• MECHANICALLY HELD RELAYS
AC or DC ... All pole combinations

• SPECIALIZED RELAYS, INCLUDING:
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... Time Delay
... Brake Winding Time Delay
... Close Differential
... Current Type, Welding
... Electronic
... Modified Arrangements

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ASCO®

ALLENPOINT will give you a bulldog grip at no premium in price!

Allen's scientific redesign of the cup diameter on set screws gives greatly increased resistance to *withdrawal* torque. You can count on Allenpoint Set Screws to stay tighter longer, under heavy strain and vibrations. This dependable premium performance of Allenpoints is yours to use without increasing the cost of manufacturing your products.

Uniform Class 3A Threads

Allenpoints' smooth, uniform threads prevent off-lead conditions like Fig. 1. With Allenpoints, you have full, even contact between the engaging flanks of the threaded members (Fig. 2) —and a tight friction lock over the entire length of the Allenpoint Set Screw.

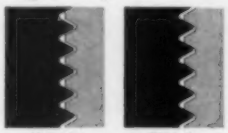
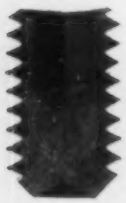


Fig. 1 Fig. 2

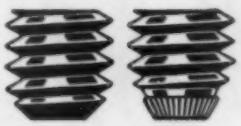
Strong, clean, deep sockets allow full wrenching leverage



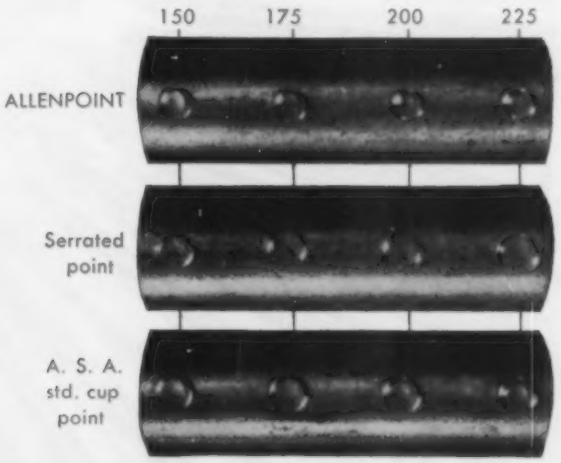
Sockets of Allenpoint Set Screws are cold forged to produce a deeper, smoother socket. No broach chips to interfere with proper seating of the key. This "pressur-forming" preserves the long steel fibers throughout the length of the screw—stronger walls allow maximum tightening torque.

One more full thread on ALLENPOINTS!

Allenpoint Set Screws have one more full thread than serrated point set screws. That means more holding power—especially important when you're using short lengths.



ALLENPOINT's performance compared for you



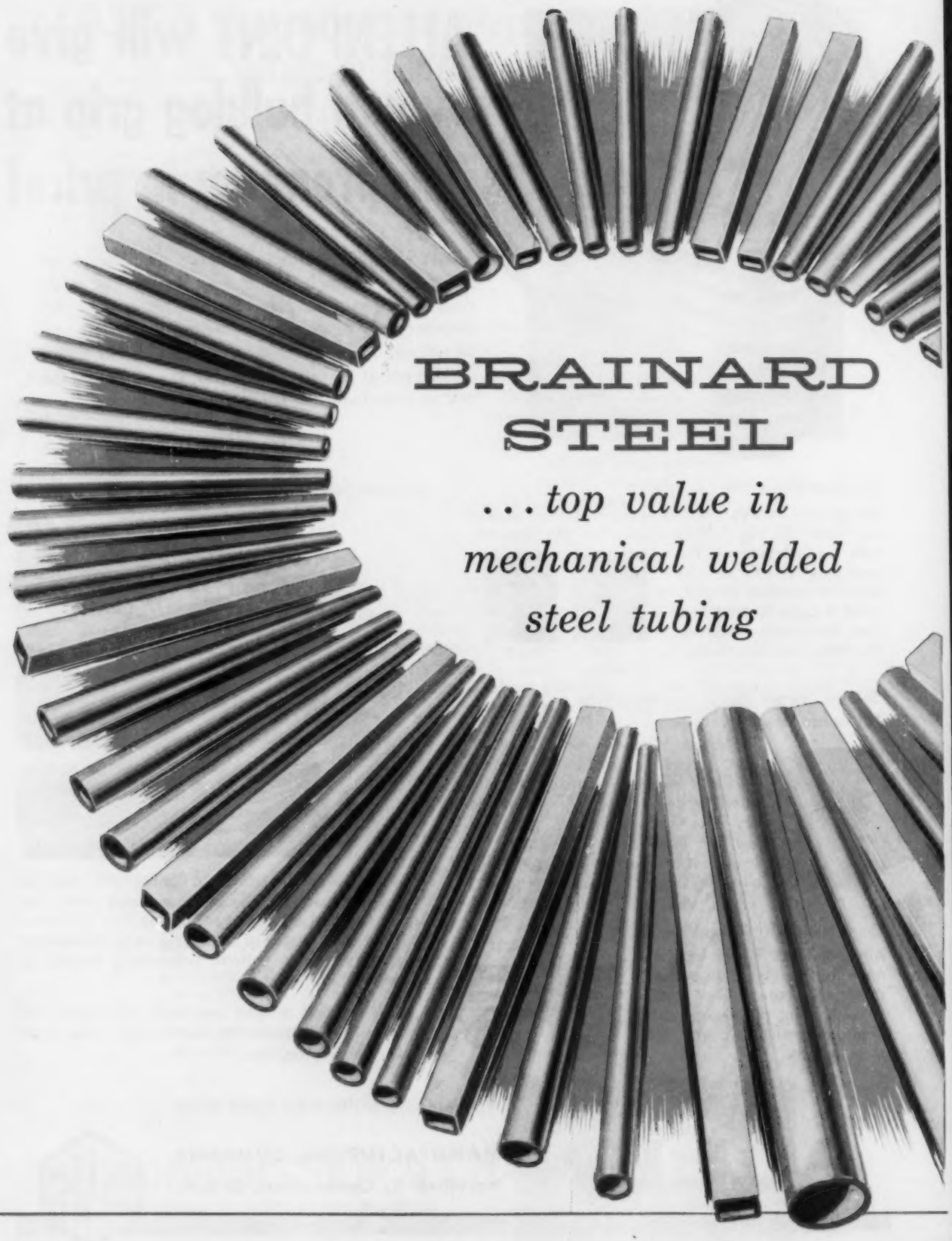
These actual-size, unretouched photographs show the cup pattern made by Allenpoints, serrated points, and A.S.A. standard cup point set screws in a 3/4" steel shaft. At each degree of tightening force, Allenpoints make a full circle pattern, penetrating deeper for greater holding power.

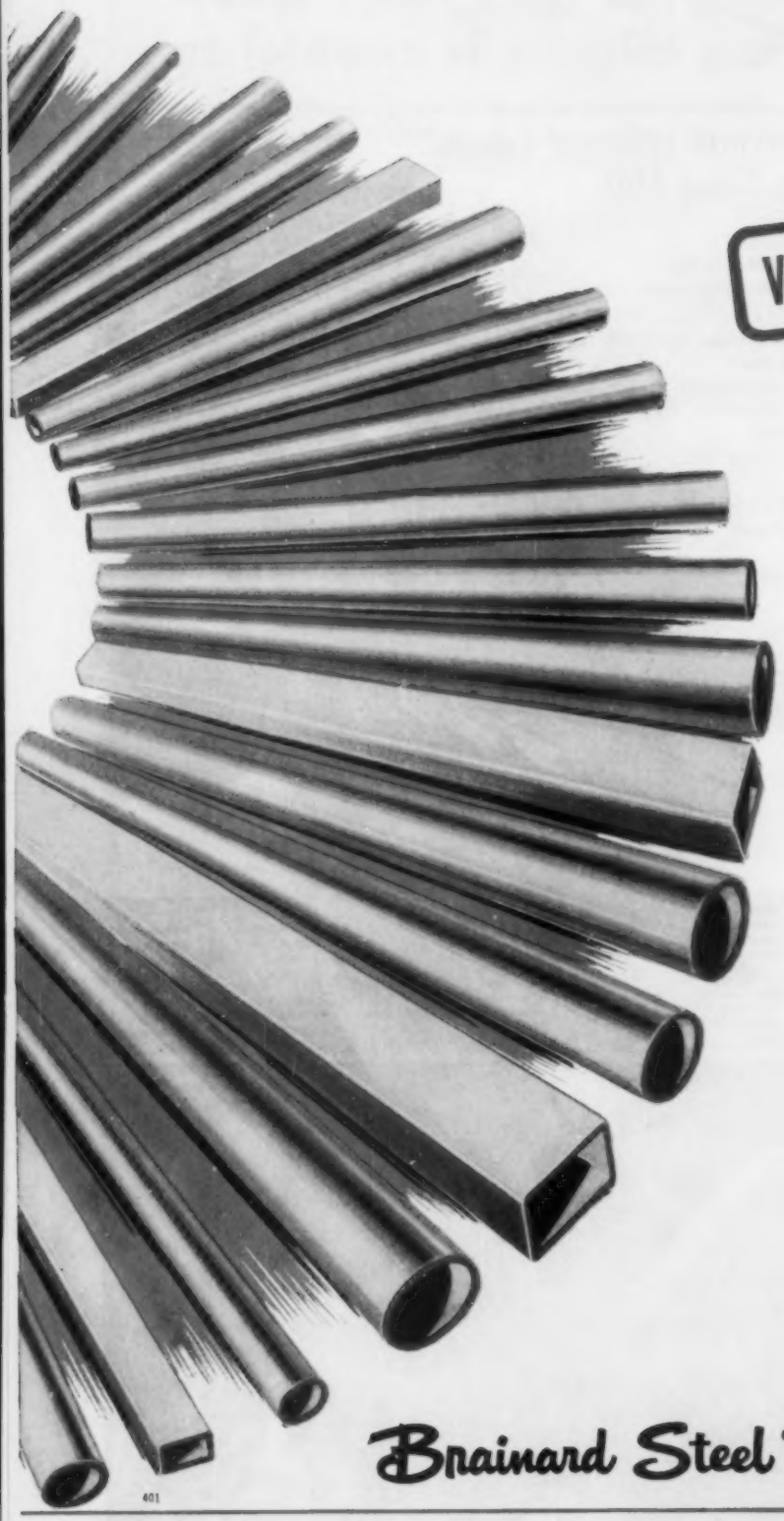
We'll be glad to send you more information and samples of Allenpoint Set Screws and other Allen Socket Screw products.

Stocked and sold by leading industrial distributors everywhere

ALLEN MANUFACTURING COMPANY
Hartford 2, Connecticut, U.S.A.

ALLEN HEX-SOCKET SCREWS HEAD


BRAINARD
STEEL
...top value in
mechanical welded
steel tubing



BRAINARD mechanical welded steel tubing is a top value buy because they give assured quality at competitive prices. Brainard Tubing, in sizes from ½" to 4" is also available in squares, rectangles, and special shapes.

VALUE = QUALITY / PRICE = BEST BUY!

Buying from Brainard has hidden values too!

DELIVERY! As a division of Sharon Steel, Brainard is assured of a constant supply of all grades of steel and can meet your delivery schedules.

VERSATILITY! Available in special shapes. Brainard Electric Welded Steel Tubing can also be swedged, pressure tested and delivered in many fabricated forms.

SERVICE! With a growing field organization, Brainard has representatives in all major cities and that's not all — Brainard will quote your requirements in short order.

so buy Brainard

SEND FOR THIS BOOKLET
For complete information on Brainard's Mechanical Welded Tubing.

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Name _____

Address _____

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Brainard Steel Tubing

SHARONSTEEL

Brainard Steel Division, Sharon Steel Corporation
Griswold Street, Warren, Ohio

LIMBERING UP LUMBER-HANDLING WITH

CYPAK

by putting memory into the carriage conveyor system at Lutcher & Moore's Orange, Texas Mill

CYPAK* static controls—outliving conventional relays 15 times over—are now being used at Lutcher & Moore's Orange, Texas Mill to control resaw conveyors on the lumber industry's first aluminum log carriage.

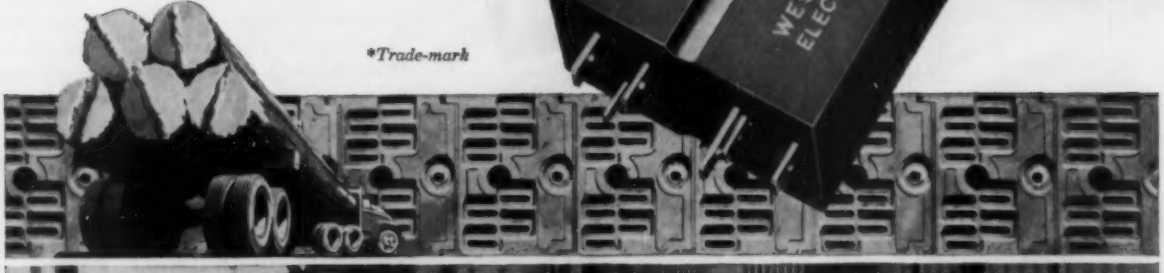
By putting memory into the carriage conveyor system, CYPAK automatically and unerringly separates waste from good boards, diverts slabs to the chipper, automatically sorts and grades, and returns boards requiring another cut back to the saw. Result: a faster, more efficient operation . . . substantial savings in materials handling . . . greater utilization of raw materials.

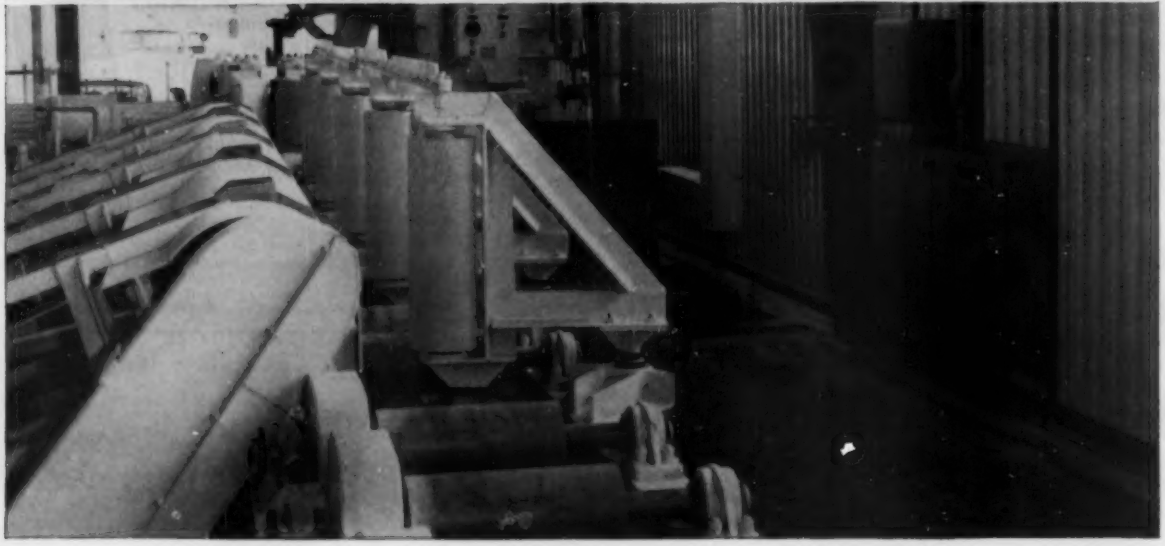
For complete information about the ways CYPAK can benefit you, call your Westinghouse sales engineer. Or, write Westinghouse Electric Corporation, Box 868, Pittsburgh 30, Pennsylvania. J-22063

YOU CAN BE SURE...IF IT'S

Westinghouse

*Trade-mark



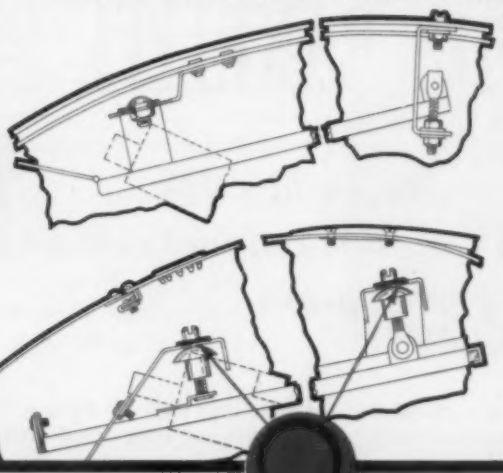


Waldes Truarc Rings cut assembly costs, improve performance of precision photo-optics equipment

Charles Beseler Co., E. Orange, N. J. uses Waldes Truarc Retaining Rings in 3 applications shown.

REFLECTING MIRROR ASSEMBLY IN OPAQUE PROJECTOR

VU-LYTE II PROJECTOR



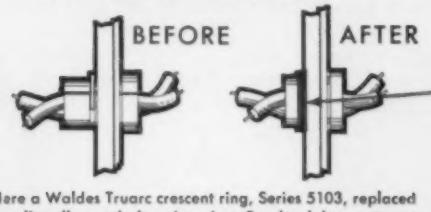
BEFORE

"The front surface mirror is the most precise optical element in a properly-functioning opaque projector," Beseler writes. "Previously we used this extremely cumbersome means of holding the mirror in position. As mirror adjustments are always required and the mirror is extremely delicate, our spoilage was terrific."

AFTER

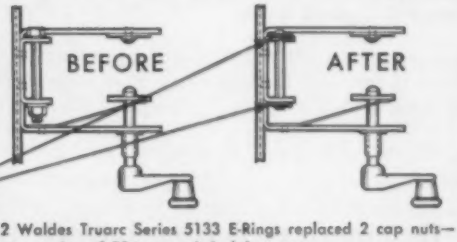
"Two Truarc Series 5100 Rings made possible complete redesign of the mirror assembly. Now mirrors can be adjusted from *outside* the projector. Rejects now are practically nil. More precise adjustment of the mirror is possible. And because of the greater ease in adjustment, we have cut labor costs $2.00 per unit."

HEAT ASSEMBLY IN PRINT DRIER



Here a Waldes Truarc crescent ring, Series 5103, replaced a split collar and clamping ring. Results: labor costs cut 50¢ per unit because of greater ease of assembly. Drier provides more uniform heating.

35 MM MICRO-FILM NEGATIVE CARRIER IN ENLARGER



2 Waldes Truarc Series 5133 E-Rings replaced 2 cap nuts—at a saving of 20¢ per unit in labor costs.

Whatever you make, there's a Waldes Truarc Ring designed to save you material, machining and labor costs, and to improve the functioning of your product.

In Truarc, you get

Complete Selection: 36 functionally different types. As many as 97 standard sizes within a ring type. 5 metal specifications and 14 different finishes. All types available quickly from leading OEM distributors in 90 stocking points throughout the U.S. and Canada.

Controlled Quality from engineering and raw materials through to the finished product. Every step in manufacture watched and checked in Waldes' own modern plant.

Field Engineering Service: More than 30 engineering-minded factory representatives and 700 field men are at your call.

Design and Engineering Service not only helps you select the proper type of ring for your purpose, but also helps you use it most efficiently. Send us your blueprints today...let our Truarc engineers help you solve design, assembly and production problems...without obligation.

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Please send new, descriptive catalog showing all types of Truarc rings and representative case history applications. *(Please print)*

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PN 099

WALDES TRUARC Retaining Rings, Grooving Tools, Pliers, Applicators and Dispensers are protected by one or more of the following U.S. Patents: 2,382,948; 2,411,426; 2,411,761; 2,416,852; 2,420,921; 2,428,341; 2,439,785; 2,441,846; 2,455,165; 2,483,379; 2,483,380; 2,483,383; 2,487,802; 2,487,803; 2,491,306; 2,491,310; 2,509,081; 2,544,631; 2,546,616; 2,547,263; 2,558,704; 2,574,034; 2,577,319; 2,595,787, and other U.S. Patents pending. Equal patent protection established in foreign countries.

Designing with BAKELITE Plastics

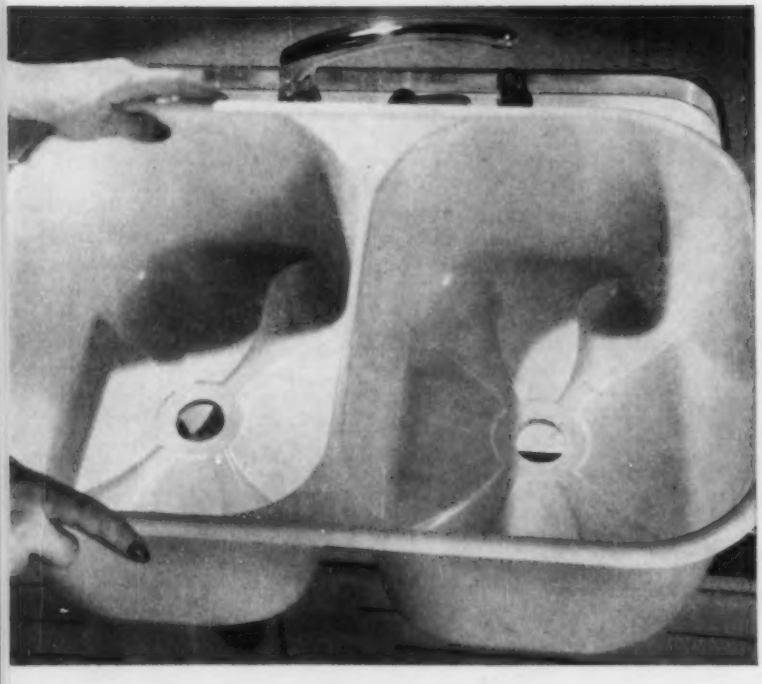
- ***Plastic converts the kitchen sink***
- ***Savings with corrosion-resistant exhaust ducts***
- ***Giant tools at small prices***

New materials create new design ideas . . . tougher coatings, parts made faster, built-in chemical resistance, or weight reduced without loss of strength . . .

Perhaps you have an idea that's been waiting for a material to make it work.

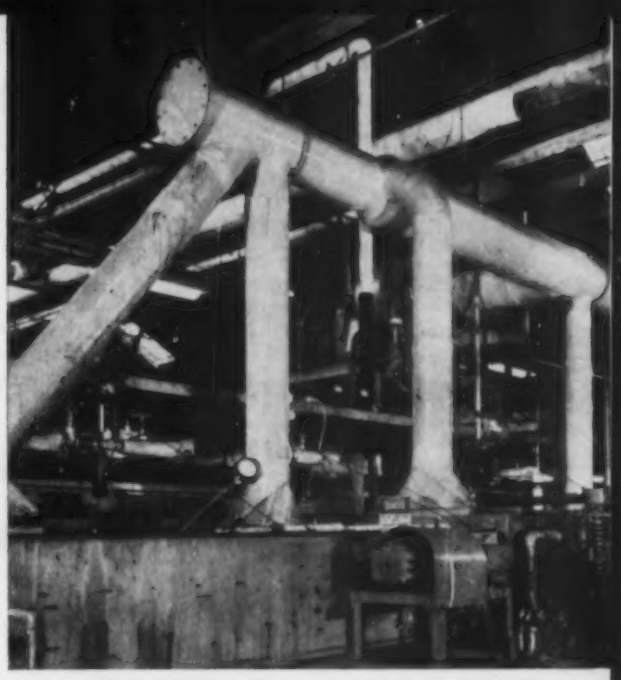
These are reasons for examining the possibilities in plastics, the newest, liveliest category of basic materials. Plastics make news in design almost daily, because they do so much so well. Your best source of plastics and information about them is Bakelite Company. Here, you can choose from styrenes, polyethylenes, vinyls, phenolics, polyesters, epoxies, silicones and impact styrenes—the largest variety in the plastics field. And in addition, you can draw on Bakelite Company experience and technical assistance for aid in applying these materials to your design problems.

1 Vacuum-formed from impact styrene—two sinks for one



This design idea is the "Dual-Sink-Tray" insert for kitchen sinks that gives the housewife a double sink in an instant. The inventor makes it of BAKELITE Brand Impact Styrene TMD-2155, extruded by Campco, because this material has all the performance advantages he requires—in addition to a high Izod impact strength (3.6 ft. lb./in. of notch, ¼ in. thick), it offers a choice of colors, resistance to household cleaners and light weight. Its resilience prevents dishes from chipping or cracking.

This product is fabricated by a simple, economical, vacuum-forming process that affords deep draws and intricate design on a mass production basis. If you are interested in BAKELITE High-Impact Styrene and the vacuum-forming operation, write Dept. ZA-145.



2 Exit corrosive atmospheres . . . through corrosion-resistant plastic ducts

Laminations of BAKELITE Brand Resins for reinforced plastics and glass fibers are extensively used for large-sized structures. They are light in weight, strong, and resistant to attack by many chemicals and corrosive fumes. Since they need no protective coating, their maintenance is low. The example shown here is part of an exhaust system in a plant for pickling brass sheets. Air laden with sulphuric acid fumes passes through hoods and ducts to a scrubber that removes the fumes and expels them through a stack—all elements in the system being reinforced plastic made of these resins and glass fiber. The scrubber, weighing 500 lbs., would weigh about 2000 lbs. if made of metal, an important factor in reducing roof stress. For more information, write Dept. ZB-145.

3 Large-scale tools made with long-lived, dimensionally stable epoxy

Jigs, checking fixtures, and similar tools, large and small, have many advantages when made from glass cloth and BAKELITE Brand Epoxy Resins. The tools shown here have already been in service for three years, forming reinforced plastic swimming pool sections. They are among the world's largest plastic tools. In another material, the cost of tools this size, with comparable durability, accuracy, and dimensional stability, would be prohibitive.

In fabrication, epoxy resins are handled as liquids, so that they can be poured into place after being mixed with their liquid hardener. They cure overnight with almost no alteration in dimensions, and after curing, can be machined or patched if design changes are called for. Finished tools are extremely hard, and resistant to chipping and cracking. Another interesting application for this epoxy resin-glass cloth construction is its use for patching dented automobile tenders, since the epoxy has excellent adhesion to metal. For more information, write Dept. ZC-145.

There's more to design with in **BAKELITE** BRAND **PLASTICS**

POLYETHYLENES • SILICONES • POLYESTERS • EPOXIES
PHENOLICS • IMPACT STYRENES • STYRENES • VINYLS

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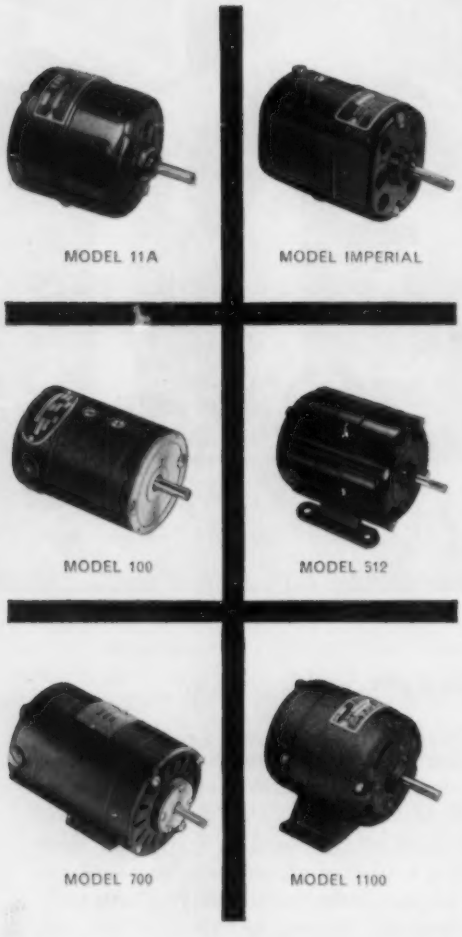

MORE THAN *50,000 DIFFERENT SPECS* HAVE BEEN FILLED BY THESE 6 HOWARD UNIVERSAL AND D.C. FRACTIONAL H.P. MOTORS

These 6 Howard motors account for over 50,000 specifications, both military and commercial. One reason for this wide use is Howard's ability to produce variations *exactly* suited to specific needs.

Howard motors have such field-proven engineering features as automatic slot cell insertion, which practically eliminates "grounds;" Zanderoll processed double dipped and double baked armatures providing deep, uniform varnish penetration for high bond strength and rock-hard coils minimizing "shorts and opens;" improved brushholder construction for accurate alignment and longer life; 2-stage, 3-plane dynamic balancing; and automatic winding for tough compact coils, giving uniform performance.

If you are currently using universal and D.C. motors from 1/200th to ½ H.P., check with Howard today.

GEAR REDUCTION UNITS		
Model	Ratio	
	min.	max.
11A	3:1	2700:1
Imperial	3:1	2700:1
100	3:1	2700:1
512	3:1	2700:1
700	21.5:1	2600:1
1100	3:1	2700:1

ELECTRICAL SPECIFICATIONS

	MODEL 11A				MODEL 100				MODEL 512			
	SERIES MOTOR	SHUNT MOTOR			SERIES MOTOR	SHUNT MOTOR			SERIES MOTOR	SHUNT MOTOR		
	15M	3.5-10M							15M	2-9M		
	5-10M	3-8M			5-10M	1.8-6M			5-10M	1.8-6M		
	1/75 No Fan	1/75 No Fan			1/50	1/50			1/10	1/12		
	1/20	1/20			1/13	1/13			1/5	1/6		
	.4	.4			.35	1.6 at 24V			1.5	1.5		
	.75	.75			1.0	5 at 24V			3.0	3.0		
	30	30			35	35			50	45		
	35	35			45	45			60	55		
	12-115	6-120			12-120	6-32			24-230	12-230		
	CW, CCW, REV.	CW, CCW, REV.			CW, CCW, REV.	CW, CCW, REV.			CW, CCW, REV.	CW, CCW, REV.		

Maximum H.P. ratings are shown. Variations are available for less power to meet application requirements.

Other Howard motors: UNIVERSAL & D.C. 1/200 to 1/2 h.p. • SHADED POLE 1/2000 to 1/8 h.p. INDUCTION 1/1400 to 1/8 h.p. • SERVO MOTORS • GEAR MOTORS • BLOWERS

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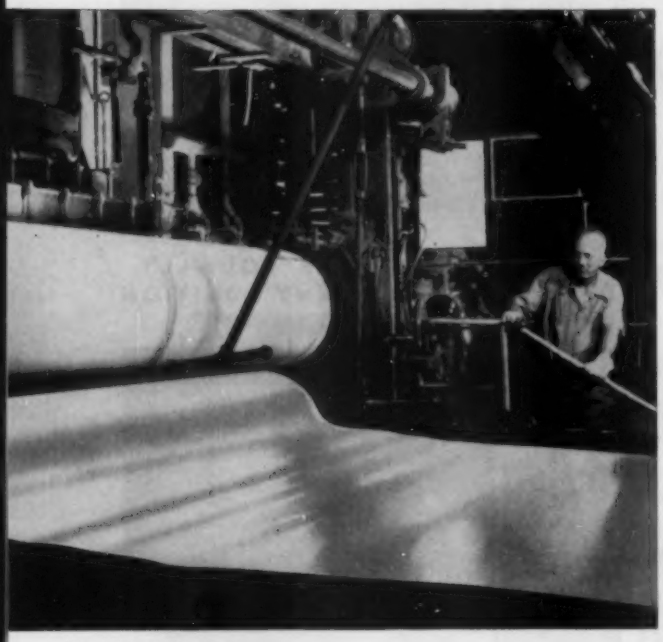
DIVISIONS: EMC ELECTRIC MOTOR CORPORATION · CYCLOHM MOTOR CORPORATION · RACINE ELECTRIC PRODUCTS

NOTHING *can equal Stainless Steel*

in its unique combination of properties



No other design material can match Stainless Steel in its combination of desirable properties: corrosion resistance, strength, hardness, beauty, cleanability and easy fabrication. If you're looking for a reliable source of supply, remember that United States Steel offers you the widest range of types, finishes and sizes.

UNITED STATES STEEL CORPORATION, PITTSBURGH • AMERICAN STEEL & WIRE DIVISION, CLEVELAND
COLUMBIA-GENEVA STEEL DIVISION, SAN FRANCISCO • NATIONAL TUBE DIVISION, PITTSBURGH
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USS STAINLESS STEEL

SHEETS • STRIP • PLATES • BARS • BILLETS
PIPE • TUBES • WIRE • SPECIAL SECTIONS

USS

UNITED STATES STEEL

For Heat Resistance

Pittsburgh Plate Glass Company wanted to increase the output of their glass tanks, so they needed better rolls to withstand the heat from the 2000° F. glass. They chose USS Stainless Steel Forgings for this critical location because Stainless resists cracking and oxidation, and retains its dimensions, even though in 24-hour-a-day service.

For Corrosion Resistance

Calera Mining Co. operates the world's largest cobalt refinery, and the process involves leaching with a sulfuric acid solution. The Stainless Steel agitators shown here hold up at temperatures as high as 200° F., despite the high acid concentrations.

For Durability

The nationally famous Norwalk Truck Lines have been using Stainless Steel trailers since 1941 and *they've never had one wear out.* Although the Stainless trailers cost a little more initially, Norwalk gladly pays the difference because the trailers never have to be painted, and they never rust out underneath.

EMMERT means SPEED .... SPEED beats DEADLINES!

OPERATES EQUALLY WELL IN ANY POSITION

EMMERT MICRO-DRAFTER

Extensive, on-the-job, research in drafting departments has demonstrated that EMMERT Micro-Drafters add one extra hour of production to every eight hours worked . . . without speed-ups.

These highly versatile units may be mounted on any standard drawing board. Write for a demonstration today.

ACCURACY . . . with an EMMERT you can draw—absolutely parallel—horizontal and vertical lines the full length and width of the board with one continuous stroke . . . and—absolutely parallel—lines at any angle the length of the scales. . . . No other drafting instrument can match this precision.

SPEED . . . an EMMERT operates with finger-tip control, changing position to any area of the board, accurately in seconds. There are no blind spots.

DURABILITY . . . EMMERT'S stainless steel construction, absolute minimum of wear points and moving parts assures unlimited use and operation before requiring service.

MICROMATIC QUADRANT

Here, precision is accomplished by an amazingly simple design. Accuracy of all angles from 0° to 360° and adjustment to 2½ minutes is assured by fine precision tooling. Full visibility at all times and clear sharp calibrations eliminate eye-strain. The entire counter-balanced unit travels the full length of the vertical blade evenly and smoothly with just-rite pressure. Just a slight thumb pressure releases the worm gear permitting the desired amount of movement. Finer settings are made by the handy worm screw.

EMMERT builds many desk and board units to be used in conjunction with the Micro-Drafter

Address inquiries to Emmert Mfg. Co., Dept P, Waynesboro, Pa.

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EMMERT MANUFACTURING COMPANY

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PERSPECTIVES

in design and development . . .

Unity Among Engineers

Another proposal for unity among engineers is currently under consideration here. The idea of M. S. Coover, 1956-57 president of the American Institute of Electrical Engineers, it has approval of that organization's board and has been sent to its 50,000 members. In mid-July, it went to other societies for consideration, and has received the support of Presidents Ryan of the 42,500-member ASME and Barrett of the AIEE.

How It Will Be Handled

According to Mr. Coover's letter in *Electrical Engineering* for June, the AIEE (and, by implication, the other four "founder" societies—ASCE, ASME, AIME, and AIChE) will limit its activities to the "advancement of technology in all branches of electrical engineering." Other activities will be handled thus:

1. The Engineers Joint Council will provide the medium for coordination and cooperation on technical matters transcending the electrical field, and will present to the public the position of the engineering profession.
2. The Engineers Council for Professional Development will provide the medium for guidance in engineering education.
3. National Society of Professional Engineers will provide the medium for the general promotion of the professional aspects of engineering in the eyes of the public and will be instrumental in the consequent enhancement of the economic status of engineers.

Most Important

The third assignment is considered by many as the most significant. NSPE, with 42,000 members, 10% of them young "engineers in training" in process of taking professional-license exams, thereby is expected to speak for the 250,000 members represented in 13 national societies and two affiliates belonging to EJC—to which it does not belong. Further, according to the Census Bureau, the nation has over 500,000 engineers, of whom 220,000 are now registered. (NSPE claims the census includes many who call themselves engineers but are not engineering graduates, says that actually only 300,000 are eligible to become professionals by registration.)

Obviously, a proposal so strongly backed as Mr. Coover's will receive serious consideration, but informed opinion is that it will ultimately fare no better than its predecessors (see table next page). NSPE appointed a committee at its recent Dallas meeting to study the proposal, but faces a difficult problem in the necessity of expanding its membership to represent all engineers if it sticks to legal registration as its accepted definition of a professional engineer.

How The Societies Feel

ASCE, the original and oldest engineering society, has not considered the proposal officially, has no present plans to present it to members. Some members feel this society would be reluctant to discontinue current professional activities of its active Department of Conditions of Practice. ASCE is the only founder society requiring an applicant to be practicing engineering actively at the time he applies for membership, is the one with the highest percentage of professional licenses, and presumably the one most heavily represented in NSPE.

AIEE and ASME would have to make only minor readjustments to

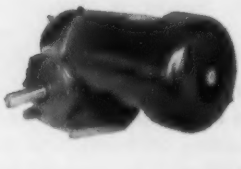
(Continued on page 65)

Now... Century announces a completely new line of fractional-HP right angle shaft type GEARMOTORS

New, "Smaller and Better" 48 and 56 Frame Century Motors

Weight reductions up to 1/3
Gearmotors operate in any position
Compact design saves space
Tapered roller bearings on low speed shaft
Finest rotary face-type oil seal on high speed shaft
Wide variety of mounting and motor types

Single reduction AGMA output speeds from 25 to 280 RPM (Double reduction as low as 4 RPM)



For floor mounting, complete with new type 56-Frame totally-enclosed, fan-cooled motor. External fan fully protected by cover. Substantial mounting on gear housing supports overhung loads on shaft. Type SC three phase motor shown. Ratings up to ¾ HP.

New IR 40 with 48-Frame motor. Gear housing shown is in one of eight possible positions. Open type single phase capacitor-start Type CS motor. Strong welded foot assembly and heavy motor frame assure smooth operation with severe sprocket loading. Ratings up to ½ HP.

Typical special purpose mounting to suit driven machine. Output shaft is vertical downward extension, properly sealed against oil leakage. Capacitor-start type motor has special smooth cover over capacitor and terminal connections to facilitate cleaning to meet sanitary requirements. Ratings up to ¾ HP.

Basic horizontal unit as assembled with 56-Frame open type motor. Motor is Type SC polyphase. Multi-speed, crane and hoist duty and other special types available. Note convenient vent and filling plugs on gear housing. Ratings up to ¾ HP.

Call your nearby Century District Sales Office or Authorized Distributor

. . . Your best motor investment is Century

91

Performance-Rated MOTORS 1/20 to 400 HP

CENTURY ELECTRIC COMPANY

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follow the proposal. Both have stressed the technological all along. Their committees on, and activities in, professional conduct and registration are a long way from ASCE's extensive interest in these phases. AIChE (understood to be considering it) and AIME have offered no official reaction. Neither is very strong in NSPE. Nor have the other societies who are affiliated with EJC—they apparently have not been consulted.

The Voice Of The Engineer

EJC has not, and probably will not, become the "voice of the engineer" it is staffed to be, according to informed sources. Their opinion is that the EJC board is carefully avoiding any activities that could be construed as "influencing legislation", so it can attain favorable tax status (501-C-3) as a scientific or educational group. Its 501-C-6 standing now contrasts with the 501-C-3 status of its constituent societies. If the societies were to drop back to 501-C-6 status in the eyes of Internal Revenue, the hoped-for tax-free gifts for the planned headquarters building in New York City might be endangered. NSPE has no such worries; it already has 501-C-6 tax status, hence freedom in political circles. It has continually sought to be spokesman for the engineering profession in public affairs.

AIEE's board has already recommended that qualified members register as professional engineers, so they can join NSPE, to overcome present obvious disproportionate representation in that group. But its proposal includes these words that strike at the heart of present NSPE policy: "NSPE should put itself in a position to represent the profession more completely by expanding its individual membership organization to include those qualified members of the profession whose work does not by law require registration as well as registered engineers." —EJT

A Short History of Attempts at Unity

1852—American Society of Civil Engineers (ASCE) formed.

1871—American Institute of Mining Engineers (now three societies in one, including "Metallurgical & Petroleum"—AIME) formed.

1880—American Society of Mechanical Engineers (ASME) formed.

1884—American Institute of Electrical Engineers (AIEE) formed.

1908—American Institute of Chemical Engineers (AIChE) formed.

1917—Engineering Council formed by four "founder" societies to meet problems of WWI.

1919—Joint conference committee proposed a comprehensive group to handle non-technical interests.

1920—Federated American Engineering Council, composed of 71 (!) engineering and allied technical groups, evolved. American Engineering Council (AEC) as administrative head.

1932—Engineers Council for Professional Development (ECPD) formed for work largely in guidance, education and training. It is *not* a "unity" candidate, nor is the 6400-member American Association of Engineers, headquartered in Chicago.

1934—National Society of Professional Engineers (NSPE) formed.

1940—AEC died—in wartime.

1941—Engineering Joint Conference formed, made up of presidents and secretaries of founder societies.

1942—AIChE president and secretary join Engineering Joint Conference.

1945—Engineers Joint Council (EJC) established by five founder societies.

1946—William Ryan, then president, Mass. Society of Professional Engineers, proposed an organization to be formed around NSPE.

1946—Committee within AIEE proposed an American Engineering Council with individual memberships, but utilizing existing organizations in its activities.

1949—Exploratory group representing 15 national societies began 2-year study, resulting in Plans A, B, C, D.

1951—EJC espoused Plan A, making EJC the unity organization, increasing size but making no provision for individual membership, as recommended.

1951—NSPE (named as unity organization in Plan D) declined invitation to join EJC.

1953—General Electric Engineers Association, Pittsfield, Mass., proposed a "super" unity organization to envelop a technical council patterned after EJC and a professional Council resembling NSPE.

1957—AIEE past president M. S. Coover proposes technological interests be handled by EJC, educational by ECPD, professional by NSPE. Founder societies would handle technological interests only. AIEE board approves. ASME president comes out in favor.

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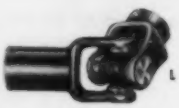

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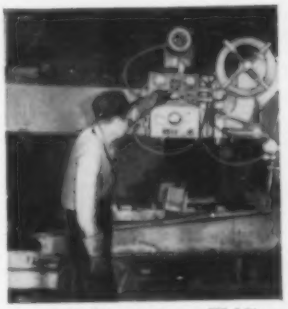

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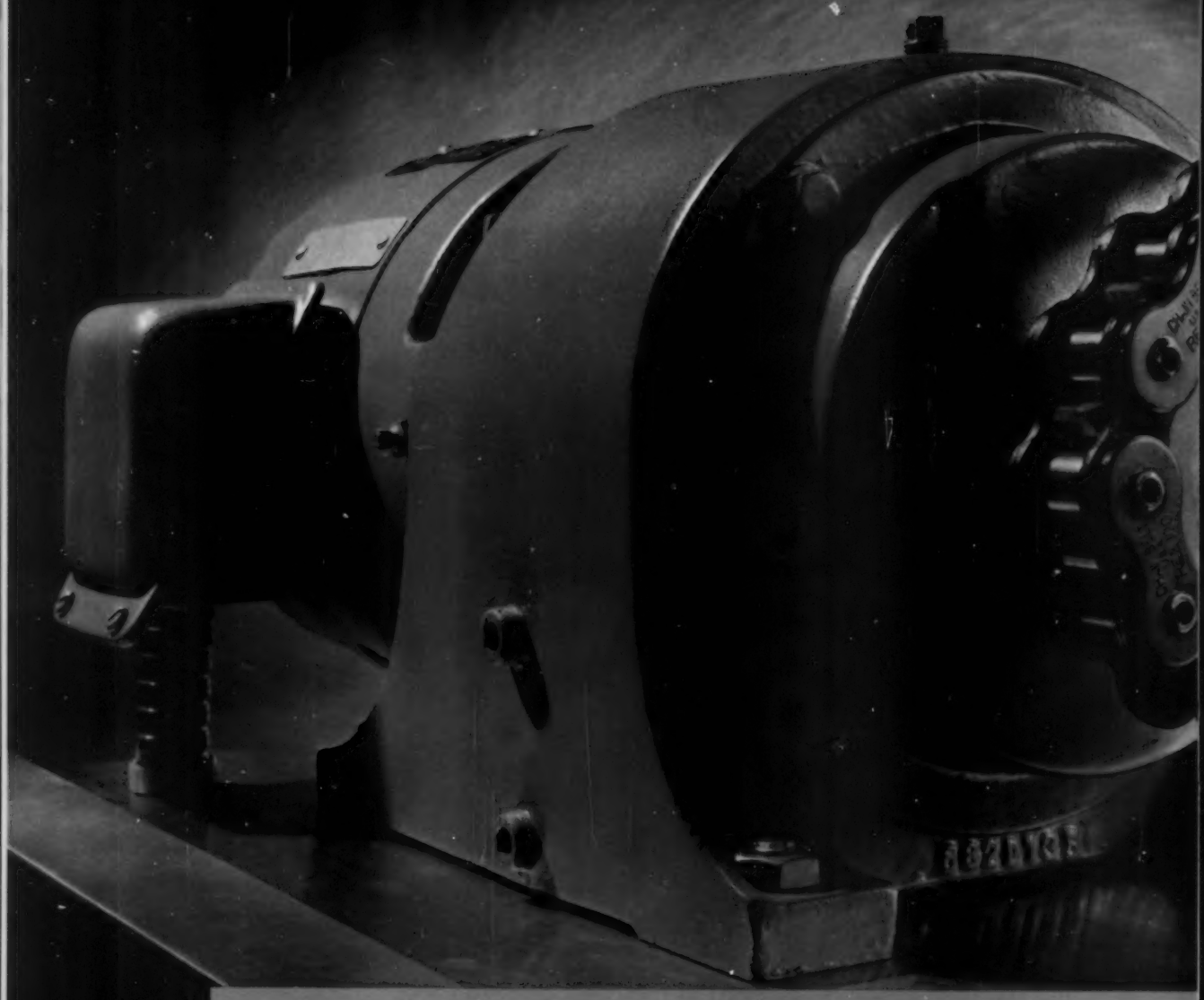

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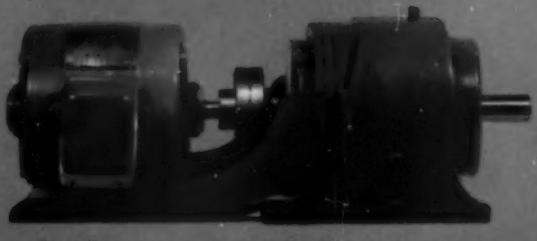

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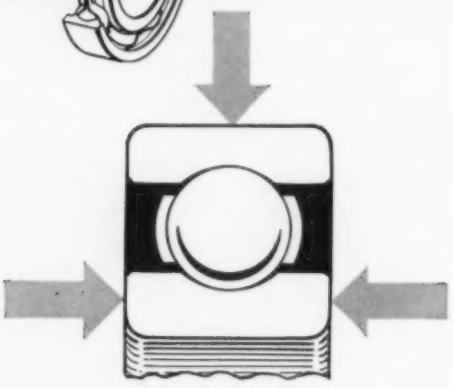

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Product Engineering

September 30, 1957

Integration for Engineers?

Let's stop kidding ourselves. Engineering is *not* a unified profession, and never has been one since we pre-empted the title. What's more, it's becoming less unified every day, despite many efforts at integration.

What interests has the construction engineer in common with the nuclear expert? Or the chemical engineer with the "black box" contriver? Or even the product designer with the power engineer (both loosely classified as mechanical engineers)?

When we say "engineer" today, we are really saying "trained expert in some aspect of modern technology," according to President Glennan of Case Institute. We have industrial, business, administrative, sales, and service engineers in addition to those in the basic technologies, each of which has split almost as fast as the atom. There are over 500,000 of us, according to best estimates—yet we are not a cohesive force (see "Perspectives," p. 63).

"There are now more than 150 different organizations of American engineers, each devoted to its own specialized interest," according to President Glennan. Only a few are interrelated–and then only at executive levels.

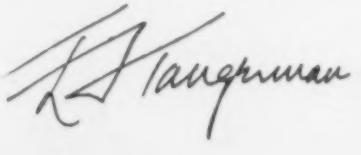
Very few of these groups are exclusively technological. They may be political, educational, or merchandising–some societies are in reality lecture, show and publishing operations enjoying special tax privileges. They do not police their membership nor do they support any over-all group that might do so. And it's unlikely that they ever will.

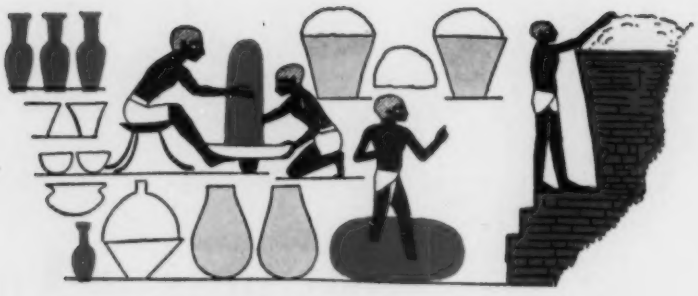
This failure to recognize and promote professional standards made state licensing necessary. England, for example, has no licensing; requirements for membership in its civil or mechanical societies are so stringent that membership is adequate evidence of ability.

In this country, the American Society of Civil Engineers requires applicants to be practicing civil engineers when they apply. The National Society of Professional Engineers requires members to be licensed engineers. Affiliation with most other groups is relatively easy; voting memberships in major ones do require engineering education and/or experience. Membership is, however, no prerequisite for most engineering jobs in industry, nor does it provide professional standing.

The professional license represents success in a limited examination, has minor status except among civil engineers, in municipal government, and on a few university campuses. Industry gives it little weight.

The answer to this situation is not for engineers themselves to stump for more recognition nor to assume that the license can provide it. We must either establish an integrated engineering association, with membership based on professional standards, or admit there can be no integration. Which shall it be?





"And they said one to another, Go to, Let us make brick, and burn them thoroughly." Genesis 11:3

ancient material

NEW LOW-EXPANSION

HERBERT SCHWARTZ *Manager, Duramic Products Div., Technion Design and Mfg. Co., New York City*

Ceramics, for which early manufacturing techniques are detailed in the Bible, are receiving new attention, particularly for parts that must withstand rapid heating and cooling. Such components as valves, bearings, pumps, nozzles, turbines, electrical fittings, and electronic insulators are being redesigned for service over 1500 F. Here, plastics must be ruled out and metals have limitations such as warpage, corrosion, excessive weight, creep, and high cost. Ceramics also have severe limitations: low tensile strength, low ductility and definite limits on close-tolerance fabrication. However, by using the good compressive strength of ceramics, structurally useful parts can be designed for unusual thermal situations.

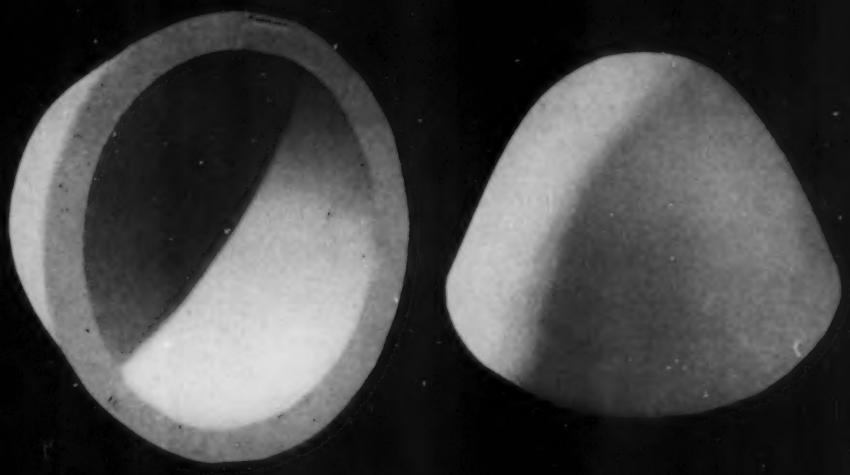
But designing a part to carry loads, even if limited to compressive ones, is only part of the problem. Thermal shock imposes abrupt dimensional changes; cracking can easily occur, particularly in parts containing sudden variations in cross-section. For such severe service as repetitive quenching in water from 2000 F without cracking, two major characteristics are required: (1) low thermal-expansion coefficient, and (2) high thermal conductivity. Ceramics manufacturers are constantly seeking such low-porosity ceramic aggregates.

A new ceramic in this family has been developed to withstand extremes in thermal shock without cracking, spalling, crazing or distortion common to porcelains, steatites and aluminas. Termed HT-2, it is a modified aluminum-silicate that can be varied in porosity from vitreous (less than 0.3% water absorption) to 25% porous, and still does not crack in such tests as these: (1) 10-sec air cool from 2000 F repeated 100 times with ⅜-in.-thick plate, (2) localized heating to melting point with oxyacetylene flame at center of a 12x12x ½-in. plate, and (3) water quench from 2100 F repeated quickly 100 times.

Comparative Properties of Thermal Shock Bodies

Material	Expansion Coefficient, in/in/Fx10⁶	Upper Temp. Limit, F†	Porosity, %	Tensile Strength, psi x 1000	Comp. Strength, psi x 1000	Hardness, Moh Scale	Dielectric Constant	Density, lb/in³
HT-2	1.0	2200	0–25	5	30	7	4.85	0.062–0.070
Cordierite	1.5	2100	15	3	40	7	4.00	0.072
Lava	2.9	1950	0.3	9	20	6	5.00	0.085
Electrical Porcelain	3.5	1800	0	5	40	7	5.00	0.085
SiC	4.4	3000	6–10	3	20	9	....	0.105
Alumina	4.5	3200	0–25	25	90	9	8.30	0.130–0.140
TiC	5.3	2800	0	112	450		....	0.217

†For continuous usage without vitrification.



Experimental nose cones for ballistic missile slip-cast prior to finish-grinding.

modernized . . .

CERAMIC for thermal shock

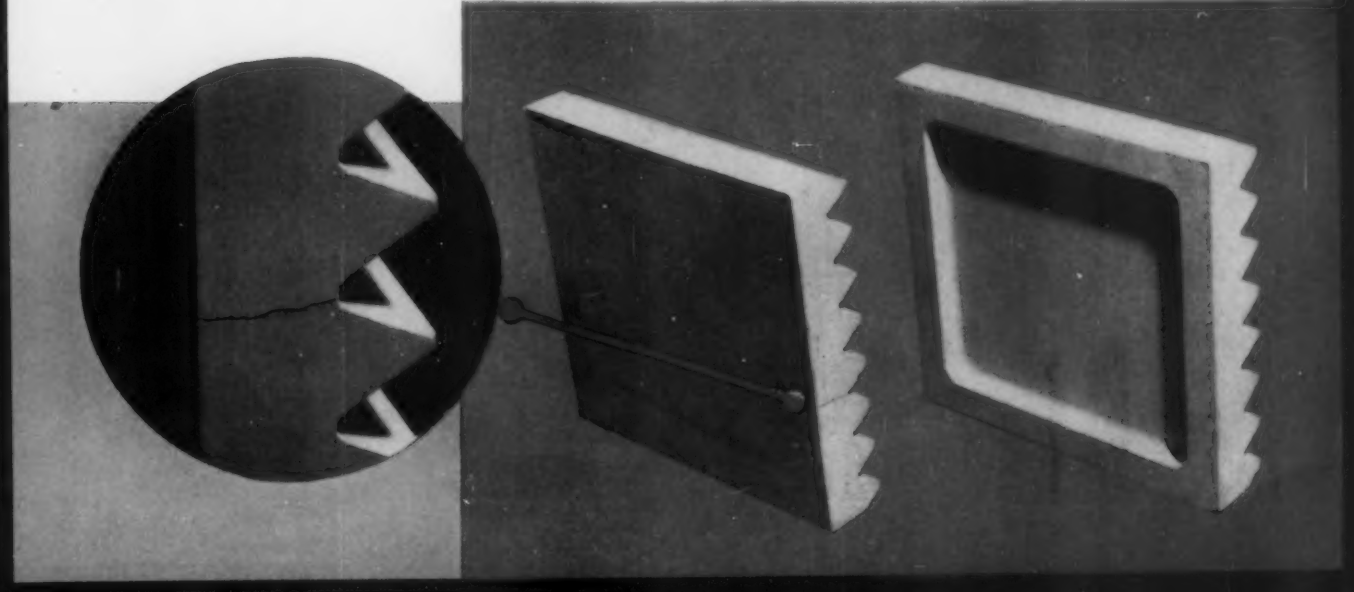
Key to the new ceramic's advantage is low thermal-expansion coefficient (Table). Note that alumina, the ceramic now most commonly used for missile radomes, has considerably superior mechanical properties but over four times the thermal coefficient, whereas cordierite has a nearly comparable coefficient but is more porous and chips easily. Titanium carbide, a typical cermet, is included to show the improvement in mechanical strength possible if economics permit.

FABRICATION

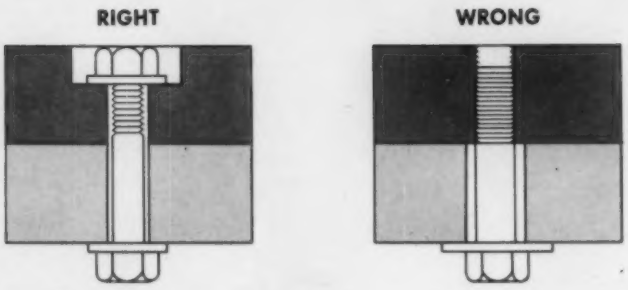
Extruded, slip-cast and dry-pressed parts (using steel dies) can be made. As with most ceramics, volumetric shrinkage during firing is a major problem; very close tolerances are difficult to control. Variations in mixing, drying and firing will all affect tolerances. Here, as-fired tolerances are ±0.010 in. per in., with closer tolerances possible on small parts.

Parts covering more than 60 sq in. are generally too large for dry pressing, so must be slip cast. Although slip casting is a more expensive process per unit, it is done in cheap plaster molds, while expensive steel molds are required in dry pressing. Consequently, production quantity will be a factor; for long runs, dry-pressed parts are most economical.

In dry pressing, the most critical tolerance should be placed perpendicular to the direction of pressing. Holes



1 Cracks (left) in brazing fixture were eliminated by redistributing material (right) to give more uniform part thickness.



2 Right and wrong way to fasten ceramic parts together. Threads induce tension; metal clamps put the ceramic in compression, a more desirable loading.

in dry-pressed parts require no taper, but a draft of about 5° is necessary in slip casting.

Machinability depends upon porosity, with the highest as-fired density producing the best surfaces. Machined tolerances of ±0.002 in. can be held, using carbide-tipped tools with water as a lubricant. Tolerances of ±0.0001 in. are possible by grinding with silicon-carbide wheels and water. As-fired surface finish is 100 micro-inch, which can be improved to 10 micro-inch by finish grinding.

Sharp corners and slots are cut with ultrasonic equipment; however, this method is still expensive and parts should be designed to use as-fired tolerances where possible. Holes can be bored or drilled with carbide-tipped tools if high speeds and low feeds are used to control chipping at the back edge.

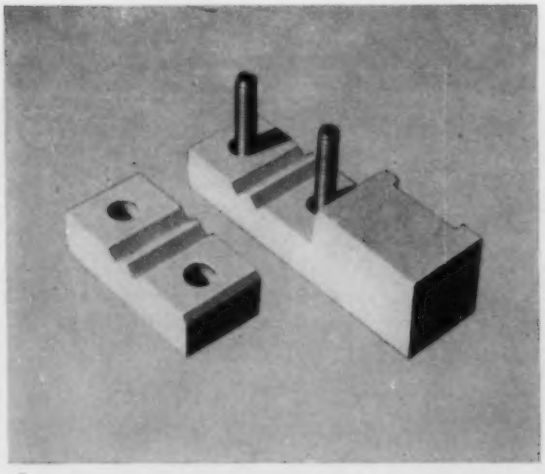
DESIGN

Mechanical strength and thermal shock resistance actually oppose each other in the design of any ceramic part. Thin sections, for example, sacrifice strength, but allow rapid dissipation of heat during rapid cooling, thereby minimizing transient thermal distortions.

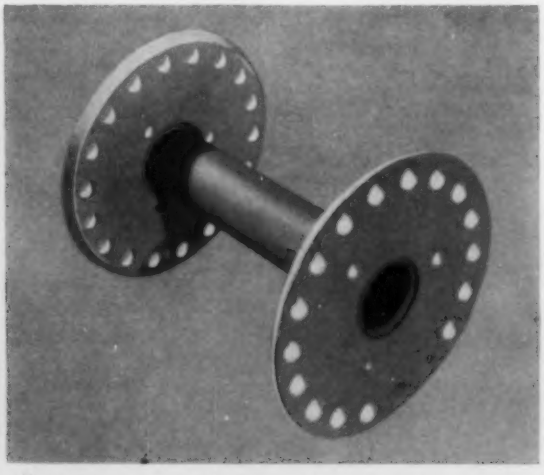
Thicknesses between ¼ and ¾ in. for HT-2 sections are the most suitable based upon experience to date, although sections as low as $\frac{1}{32}$ in. may be possible. Rapid changes in section and sharp corners are undesirable and often cause cracking in firing, although redistribution of material helps. For example, the cracking shown in Fig. 1 at the V-roots of a brazing fixture occurred because the heavy root thickness and the "fin" effect of the triangular spacers combined to prevent uniform cooling. Also shown is how thinning the heavy section by undercutting gave a crack-free part.

Threads can be pressed, but should be rough series if used, and eliminated where possible because of the modest tensile strength of the ceramic. In addition, shrinkage during firing requires special taps for threaded holes, which increases part cost. Compression methods of fastening are preferable, Fig. 2, and tight fits with metal parts should be avoided because of the mismatch in thermal-expansion coefficient. However, the ceramic can be coated by metal-spray technique for joining to metal parts by soft soldering or silver brazing. High-temperature ceramic adhesives can also be used.

Shock mechanical loading is the nemesis of all low-cost ceramic materials. In metals, ductility functions as a life-preserver by redistributing loads through local



3 Thermocouple insulators of HT-2 replaced porcelain for jet-engine tests. A total of 143 insulators around the engine body must resist a thermal change of 70 to 1600 F in 5 sec.



4 Induction-heating end plates for steel cylinder prevent warpage during hardening of outer cylinder surface. Temperature difference from disk edge to holes is about 1600 F.

yielding. Without this mechanism, ceramic parts must be designed with gradual transition between different cross-sections, liberal radii where re-entrant corners are needed, and for compression loading where possible. Although excessive caution in design seems implied, such is actually not the case: Only need is for a shift in design thinking—as when going from cold-rolled steel to cast iron.

APPLICATIONS

This new low-expansion ceramic presents two possible avenues for product improvement: (1) better ceramic parts through improved thermal shock resistance, (2) substitution for metal parts where warpage and cost are problems. HT-2 ceramic material costs about the same as copper ingot and weighs one-fifth as much as steel. When the material is suitable, savings are possible, particularly where low-expansion alloy steels are involved. Four examples will illustrate these points:

1. Thermocouple insulators, Fig. 3, for jet-engine tests undergo severe thermal shock because of rapid engine warm-up and cool-down. The HT-2 ceramic insulators, dry pressed in steel molds for minimum costs, have thermocouple wires kept separate by V-grooves and clamped by stainless hardware. Note that loading is compressive, hence sharp corners are permissible.

2. Induction-heating fixture, Fig. 4, is made of two ceramic disks that clamp a 5-in.-dia steel cylinder sandwich-fashion. Water passes through the 18 holes in the end plates and impinges on the inner cylinder surface to prevent that surface from annealing. The new ceramic provides good dielectric strength and high thermal shock resistance.

3. Shielded-arc welding nozzle, Fig. 5, conducts argon gas to the weld area where tungsten-arc flash temperatures exceed 3000 F. Grade "A" lava and porous alumina are commonly used, but lava nozzles burn away fairly rapidly, and alumina tends to shatter thermally when the arc is turned off.

4. Brazing plates, Fig. 6, for stainless-steel honeycomb structure, replaced Inconel plates for 70% lower cost and one-fifth the weight. HT-2 plates were rough cast and precision ground to ±0.001 in., a tolerance retained after four months service. Graphite, an alternate material, is easily machined and has good thermal shock resistance, but rapid wear and a tendency to embrittle stainless steel make it undesirable here.

EDITOR'S NOTE: These recent articles reflect the increasing use of ceramic components in design:

"Flame-Plating for Wear Resistance" Sept '56, p 202. Hard surfaces of tungsten carbide and low-porosity alumina are laid down by detonation process.

"Ceramic Magnets" Dec '56, p 143. How to utilize the high coercive force and potential energy of ceramic magnets; holding, driving and generator applications.

"Glass-to-Metal Seals" Jan '57, p 188. Five types of seals, design factors in selecting glass-to-metal seals, alternates to sight-glass assemblies.

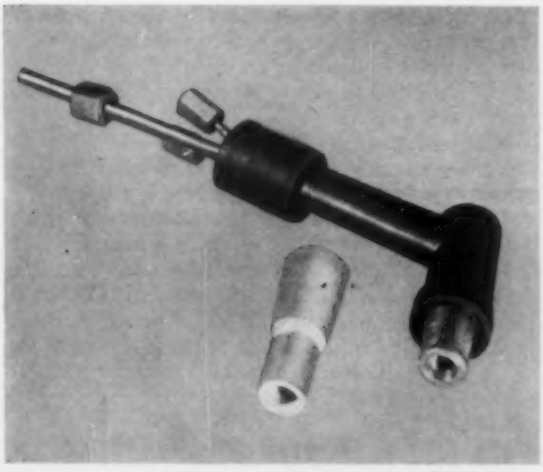
"Nitride-Bonded Silicon Carbide" Feb '57, p 135. Man-made material bonded with silicon nitride yields kiln-fired parts with remarkable resistance to heat abrasion and corrosion. Applications covered include refractory pump for transferring molten aluminum.

"Industrial Application of Ceramics" Design Digest, Mid-Oct '56, p C12. A survey of common idustrial refractories and properties of importance in product design.

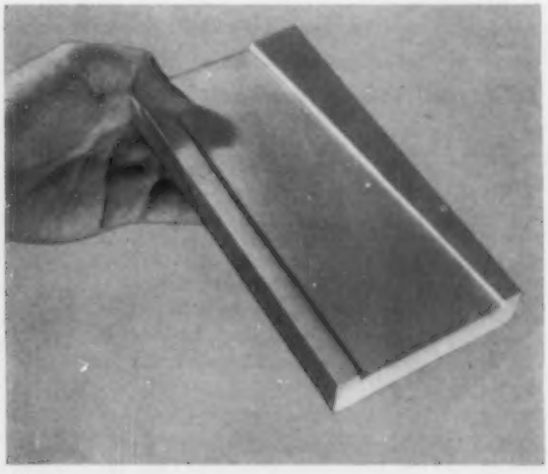
COMING SOON

An Article on Titanium Carbide

By John C. Redmond, Director of Research, Kennametal, Inc. It will include a discussion of physical and mechanical properties; how to select the best composition; how to design and assemble parts for optimum service life.



5 Shielded-arc welding nozzle of HT-2 ceramic resists thermal shattering when torch is started and stopped. High dielectric strength of ceramic prevents shorting of arc. Tec Torch Co.



6 Brazing plate for stainless honeycomb structure replaces costlier, heavier Inconel fixture. Brazing cycle requires 2000 F over 6 hr, followed by rapid cooling to room temperatures.

Thrust Bearing . . .
is self-aligning and water-lubricated, has inserted carbon-graphite bearing surfaces.

Water-lubricated Fluid-film Bearings Are Practical

STANLEY ABRAMOVITZ
Continental Bearing Research Corp.
New York City

Corrosion, low viscosity, and poor boundary lubrication are the three drawbacks to water as a lubricant. But all three can be controlled by proper design and choice of materials.

Until recently, water lubrication was regarded with considerable distrust. Today, however, with proper attention to design details, it can give high performance in critical applications. But in comparison with oil lubricants, water has three important weaknesses that must be allowed for in bearing design.

1. Low Viscosity. Because viscosity of a conventional oil is approximately 100 times that of water, the film thickness in a water-lubricated bearing is approximately $\frac{1}{10}$ the thickness of an oil film. Smooth bearing surface and precise contour are important to prevent excessive wear or seizure. It may be necessary to filter the water down to one or two microns.

2. Corrosion. For bearing materials immersed in water, corrosion is a limiting factor—not so much in weakening the structural components as through contamination of water by corrosion products. These particles can cause seizure through scoring and wear.

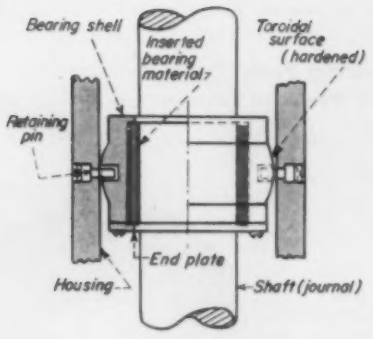
Also, oxides build up when bearing surfaces are in static contact for a period of time. During a long shutdown period bearings must be run periodically to flush away oxide particles.

Corrosion-resistant materials are available for the structural components of a bearing, but materials for bearing surfaces also require good bearing properties.

3. Boundary Lubrication. Oils coat bearing surfaces with a few layers of the lubricant molecules. This boundary lubrication reduces friction when the bearing is started (before a significant hydrodynamic film is developed) and as the bearing comes to rest. Although little boundary lubrication may be expected from water, it is increased by special bearing materials, bearing-surface profile or additives for the water.

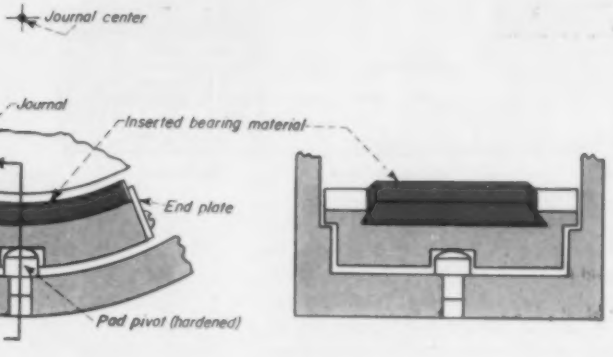
BEARING DESIGN

Because the oil film is thin, water-lubricated journal bearings must have small radial clearances. With large journal diameters, long span between bearings, or ele-



1 Bearing Shell Is Free . . .
to pivot in the housing—this is a self-aligning journal bearing with insert of low-strength bearing material.

2 Journal Circumference . . .
is supported by three or five pivoted pads instead of a solid sleeve. ▼



vated operating temperatures, self-aligning bearings are essential.

Features required for water lubrication of a 360° journal bearing are shown in Fig. 1. To permit self-alignment the bearing shell has a toroidal surface midway along the bearing length. This surface is hard, with a large radius of curvature to minimize surface stresses, or the cylinder housing is hardened to leave the toroidal surface relatively soft. For high radial loads, both surfaces should be hard. Diametrically opposed pins absorb bearing friction torque and support the bearing in the housing. Pin ends fit loosely in the bearing shell.

Some desirable bearing materials have low strength and low resistance to shock loads, and must be retained in a shell or cartridge. The bearing sleeve in Fig. 1 is inserted in the shell with a stop at one end and a removable end plate at the other. A shrink fit should hold low-strength materials in the shell to place them under compressive stress. This protects the material during fabrication and also when subjected to shock loading and vibration in operation.

Because little power is absorbed by a low viscosity fluid, high bearing speeds are practical. However, the combination of high speed and low load tends to hydrodynamic instability (whip or whirl) in which the journal center rotates about the axis of the bearing. If metal-to-metal contact occurs the bearing can destroy itself in a short time. A tilting-pad journal bearing, Fig. 2, will prevent instability in most cases, but a stability analysis should be made.

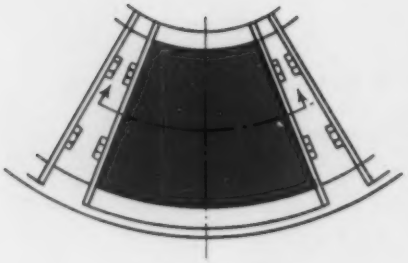
The self-aligning feature is not always necessary. When cost is important and deflections and distortions are low, a fixed bushing may be adequate, although at some sacrifice in life and reliability.

Sensitivity to alignment and distortion is even more critical in thrust bearings where shaft deflections or distortions are magnified at the thrust face. If reliability is essential, an equalized tilting-pad bearing is used even under moderate loads. Fig. 3 shows how equalizers leave each pad free to move up or down to take an equal share of the load, regardless of perpendicularity between thrust-collar face and shaft.

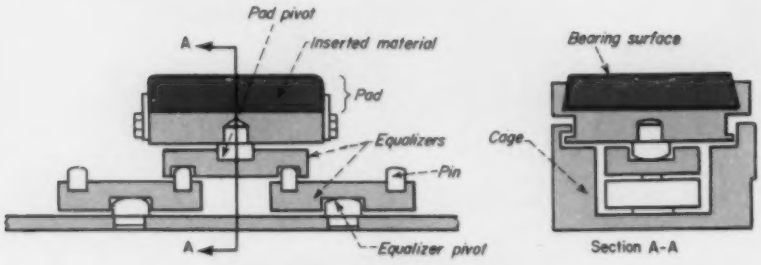
The equalizers must be completely free as in Fig. 3, which is a pin construction with considerable field use. Contacting portions of pins—and pad and cage pivot pins—must be hardened to minimize wear and fretting.

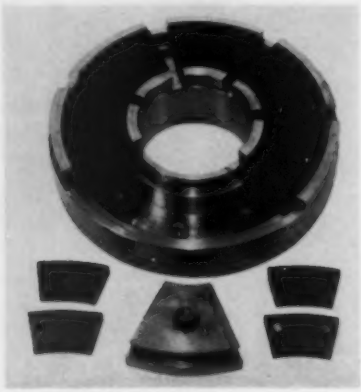
Bearing inserts of low-strength material should have a zero or slightly loose fit in the retainer. If the pads are shrunk in the retainers and the bearing surfaces conditioned at room temperature, the insert will either relax or tighten when the operating temperature changes. Distortions of the order of 100 microinches can be critical. A dovetail with end plates or a center key are effective retaining methods.

Not too long ago a series of tests were made by Levinsohn and Reynolds using a tapered-land thrust bearing with water as the lubricant. The tapered land bearing (Fig. 4) has a series of fixed inclined pads that are machined on the face of a solid ring. The pads had both radial and circumferential taper. Results indicated that the bearing (2¾ in. OD x 1¾ in. ID) could carry at least 110 psi at speeds from 860 to 3450 rpm, with the water temperature at 80 F. Six grooves were used; the circumferential taper was approximately 0.0007 in. deep at the lowest point and 0.0003 in. per in. down towards the inner diameter. The flat and untapered portion of each pad represented from



3 Thrust Bearing Pads . . .
are free to pivot individually to conform to the thrust plate.





⅓ to ¼ of the total pad area. Although this appears to be a simple and inexpensive thrust bearing care should be exercised in recommending it for particular applications. The degree of taper is critical and would require a costly scraping jig to maintain control in production. If the bearing is required to start and stop many times during its life, wear will occur (before a film is developed) and the taper will eventually be worn down. Furthermore, there is no provision for misalignment and the face of the thrust collar must be accurately parallel to the bearing face.

The simplest thrust bearing is a flat washer, comparable to a face seal. Loads must be kept under 5 psi or wear rate is high. Such a bearing may be used as a guide when loads are relatively light and intermittent.

BEARING MATERIALS

Major factors in selecting materials for bearing surfaces are compatibility (for lowest friction and wear), conformability, and corrosion. Babbitts and straight carbon steels have poor resistance to corrosion. Corrosion also limits the use of copper-based alloys, particularly at elevated temperatures. These material combinations are recommended:

Bearing Surface	Journal Material
Graphitar #14	Stellite #1, #6, #12
Graphitar #39	Nitrided stainless steel
	Hard chrome-plated stainless steel
	Hardened 17-4 PH
Cold-pressed aluminum oxide	Cold-pressed aluminum oxide
	Bonded aluminum oxide
Boron carbide	Tungsten carbide

Graphitar (carbon-graphite) is compatible with many materials, provides its own solid boundary lubricant, can be machined easily, and conforms (by wearing) without serious damage to the journal surfaces. Because of its relatively poor resistance to shock loads, carbon-graphite must be well supported and retained.

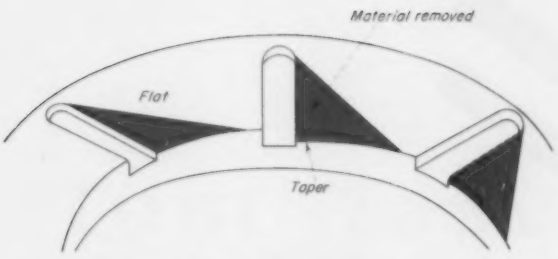
Ceramics and sintered carbides have good wear characteristics and are free from galling, but are more sensitive than carbon-graphite to contaminants in the water. Water should be filtered free of solid particles down to a maximum of 2 microns. Shock resistance is approximately four times that of carbon-graphite but adequate support and retention is still required. A relatively new process of depositing aluminum oxide and tungsten carbide on a base material (see Editor's Note) may possibly avoid expensive methods of supporting these relatively brittle materials. Since the deposit can be thin it will resist reasonable load and thermal shocks.

Rubber and wood may also be used. Lignum vitae is corrosion resistant, has high resistance to wear and compression, and its high resin content gives self-lubricating properties.

Rubber is effective when abrasive contaminants are present in the water. Usually a rubber journal bearing is made with longitudinal grooves, Fig. 5, to provide passages for the water acting both as coolant and lubricant. The grooves also collect abrasive particles that are eventually washed out of the bearing. Resilience of the rubber prevents damage to the journal from abrasive particles.

Stellites have excellent resistance to corrosion and good compatibility with carbon-graphite. Types available only as welding rod must be puddled on the surface of a base material, usually stainless steel—Type 304, 316 or 321 for best corrosion resistance. Type 347 has better corrosion resistance when subjected to high temperatures, as in welding.

Although the 400-series stainless steels can be used, their corrosion resistance is inferior to the 300-series. Types 410 and 440C can be heat-treated to a relatively high hardness; for the 300 series, other methods such as nitriding are required to obtain a surface harder than RC45, and some corrosion resistance is lost. Harden-



4 Tapered-land Thrust Bearing . . .
has no self-aligning features and requires the mating runner to be held to flatness and squareness in tenths of thousandths.

able stainless steel, 17-4PH and 17-7PH, requires careful heat treatment to retain best corrosion resistance. Hard chrome plate makes a good surface, but heavy deposits may chip or flake during use.

STRUCTURAL MATERIALS

Bearing supports are generally made of copper alloys or stainless steel, with 300-series stainless selected for maximum corrosion resistance. Free machining Type 303 has less corrosion resistance than Types 304, 316, 321 and 347.

Hardened surfaces are needed for articulating components. The aligning toroid and pad pivot of the journal bearing, and the pad and equalizer pivots of the thrust bearing, should be as hard as practical. With 400-series stainless, the entire pin or pivot can be hardened; with 300-series, other methods must be employed, such as adding a Stellite face. If necessary, the entire pivot can be cast Stellite or tungsten carbide. Armco 17-4PH or 17-7PH stainless can also be used.

LOAD CAPACITY

Hydrodynamically, water has the same characteristics as oil: viscosity decreases with increasing temperature, and it can be considered incompressible. But water has a relatively low boiling point at atmospheric pressure and cavitation may be encountered when operating at elevated temperatures.

Basic equations for hydrodynamic lubrication apply to an analysis of load capacity, power loss, flow, and temperature rise in water-lubricated bearings. Because of water's low kinematic viscosity, it is necessary (even at low speeds) to analyze for turbulence in the fluid film. For thrust bearings, pad-surface profile must be also considered.

Considering speed, viscosity, and bearing dimensions as constant, the load capacity is inversely proportional to the square of the film thickness. Surface roughness, and, therefore, the practical minimum film thickness, limits the maximum load a bearing will carry successfully. Although water-lubricated bearings have worked with a calculated film thickness of only 0.0001 in., thickness should be on the order of 0.0005 in. for reliable operation. Bearings have operated successfully at 100 psi with 50 ft/sec velocity. But in general, the maximum is 40 psi with 25 psi for general use.

Unit loads for various film thickness are shown in Fig. 6 for a typical bearing operating with oil, water at two temperatures, and air. Values shown will vary with bearing dimensions and velocity, but indicate the film thickness that may be expected with water lubrication. These films may seem small and unreliable, but safe operation can be obtained with a correct design if surface finish is 8 microinches or finer, and the lubricant is clean.

POWER LOSS AND TEMPERATURE RISE

Power loss will be significantly lower with water than with oil. For a given velocity, power loss is a function of viscosity and film thickness. Reduction in power loss with low-viscosity water is somewhat offset by the small film thickness, which is inversely proportional to power. However, the reduction in power loss is significant, particularly when operating at a relatively low unit load as shown in Fig. 7, which compares power loss between air, oil, and water in the same bearing.

Temperature rise of the fluid as it passes through the bearing is usually quite low, 5 to 10 F, and little cooling may be required because the heat can be dissipated to surrounding air through piping or casing walls. The relatively high specific heat of water (twice that of oil) further limits the rise of fluid temperature. When operating temperatures are relatively high or load conditions produce a large temperature rise, cooling must be adequate to prevent water flashing into steam.

TURBULENCE

If turbulence is present the film thickness may be reduced or even destroyed, and the power absorbed will increase to many times over laminar flow conditions. Little is known about the effect of turbulence on film thickness. Film thicknesses are small, so the bearing should be designed for laminar flow conditions. For the thrust bearing, a Reynolds' Number of 700 is the upper limit. For a journal bearing, the following equation will determine the speed above which turbulence will exist for a specific set of bearing conditions.

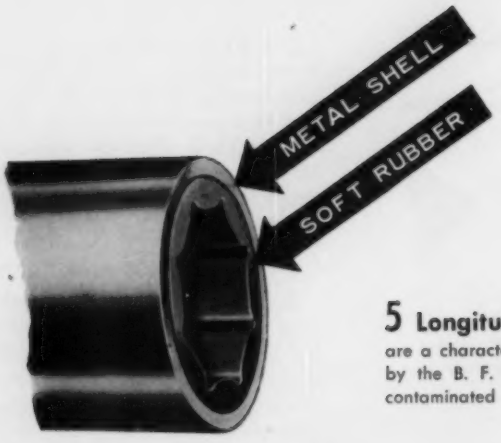
$$N = \frac{41.1\ \nu}{\pi\ DC}\sqrt{\frac{D}{2C}}$$

where N is speed in rpm, D is journal dia, C is radial clearance, and ν is kinematic viscosity in in.^{2}/sec.

SURFACE PROFILE

For pad or segmented bearings, surfaces of the bearing segments are lapped or ground flat, although some recent studies show the importance of a spheroidal-convex shape for certain applications. The pad pivot should be centrally located if the bearing is used for both directions of rotation. While theoretically a film should not develop with a central pivot, these bearings do operate. This is generally attributed to the convex distortion of the pad surface under loading, and thermal gradients across the thickness of the pad. In water lubrication, however, loads and thermal gradients are relatively low, and the pad surface must be crowned.

Height of the crown is approximately one-half the

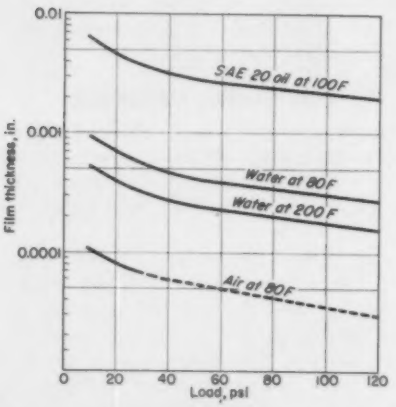


5 Longitudinal Grooves . . .
are a characteristic of this rubber bearing made by the B. F. Goodrich Co. for lubrication with contaminated water.

minimum film thickness that would be developed with a flat pad at its optimum pivot location. Where the film thickness is small (0.0002 in.) at high loads the crown should more closely approach the film thickness.

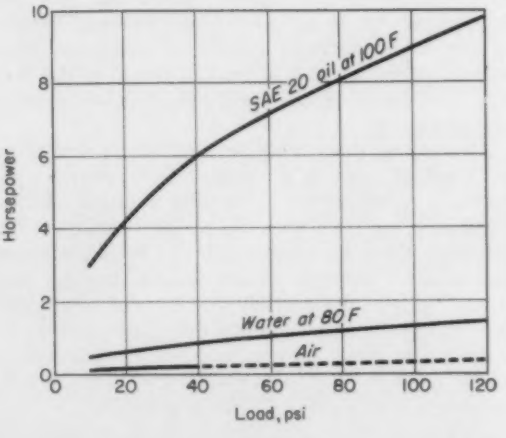
With some materials, apparently, a convex surface also reduces starting friction. This help from the surface profile can be the difference between success or failure of a bearing.

EDITOR'S NOTE: For the materials listed as bearing and journal combinations, suppliers are: Graphitar, U. S. Graphite Co.; Stellite, Haynes Stellite Co.; hardenable stainless, 17-4PH and 17-7PH, Armco Steel Corp.; cold-pressed aluminum oxide, boron carbide, and process for depositing aluminum oxide, Norton Co.; process for depositing tungsten carbide, Linde Air Products Co. (see article Sept '56, p 202.)



6 Film-thickness Comparison . . .
of air, oil and water is shown here as a function of bearing load for a typical bearing.

7 Friction Loss . . .
for air, oil, and water-lubricated bearings is shown here as a function of bearing load.



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Test Results Guide – high-temperature design of bolted assemblies

STEVEN S. SILWONES, *Metallurgist*
ROBERT A. DEGEN, *Project Engineer*
Elastic Stop Nut Corp. of America, Union, N. J.

Here are materials recommended for bolts and structures subjected to temperatures up to 1300 F. From tests on locknuts you can compute the effects of expansion, also stress rupture, relaxation and reusability.

Of three inter-related factors that affect performance of a bolted assembly at high working temperature, two are now predictable from a series of tests that simulate actual conditions. These are: stress-rupture strength of the locknut, and relaxation occurring in the locknut and bolt.

The third is the problem of thermal expansion. This can be avoided by selecting materials with similar rates of expansion for all three components—structure, bolt and locknut.

STRUCTURE MATERIALS

Most common materials for use in the range of 60 F to 400 F are aluminum alloy 7075-T6 and the alloy steels 4140 and 8740, Table I. The steels are usually cadmium-plated to improve corrosion resistance, obtain compatibility with aluminum structures and reduce frictional forces between mating elements. Aluminum alloys are generally considered poor in strength-weight ratio above 300 F and some engineers limit their use to slightly above 200 F.

400 to 800 F . . .

Above 400 F, materials usually considered include some alloy steels, the 300 and 400 series stainless steels, and titanium. Nickel or nickel-cadmium alloy plating can replace cadmium plating here to give protection against corrosion and oxidation. Strength of some of the materials drops considerably at 800 F. However, they can be used in short-time applications at this temperature range. For instance, missile designers often base their choice on the short-time tensile strengths, Table II.

Up to 900 F . . .

Best choice may be martensitic chromium steels modified with Mo or Va, such as 422 M (modified). The steels 17-7PH or 17-4PH can also be used even

TABLE I — High-temperature Bolt Materials
100-hour stress-rupture strength, psi

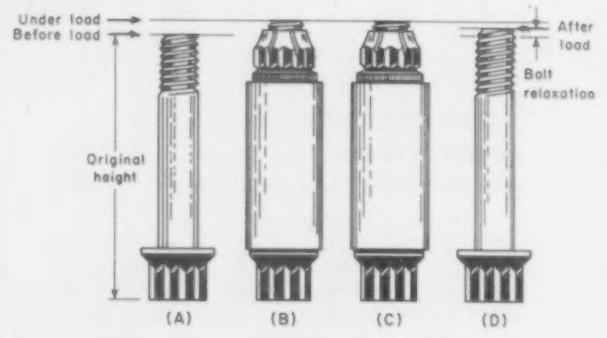
Material	Temperature, F										
	200	300	500	600	700	800	900	1000	1100	1200	1300
7075–T6	65,000	41,000	10,000	6,500							
4140				100,000	85,000	62,000	44,000				
17–7PH				162,000	141,000	124,000	73,000				
17–4PH				154,000	134,000	130,000	81,000				
321 (Ann.)						55,000	52,000	46,000	40,000	26,000	
422 Mod.						105,000	96,000	85,000	62,000	27,000	
A–286						135,000	118,000	100,000	81,500	63,000	44,000
Inconel X							130,000	115,000	100,000	80,000	60,000

TABLE II — Typical Short-time Tensile Strength (Psi) of High-temperature Materials

Temp., °F	Aluminum	Stainless		Steel	Titanium 6AL-4V		Stainless, age hardened			Super Alloys	
	7075-T6	321 (ann.)	410	4140	Heat-treated	Annealed	17-7PH	17-4PH	422 Mod.	A-286	Inconel X
70	72,000	85,000	175,000	131,000	175,000	132,000	205,000	196,000	177,000	146,000	162,000
200	66,000	74,000	175,000	131,000	156,000	118,000	205,000	196,000	177,000	146,000	161,000
400	38,000	65,000	170,000		128,000	104,000	189,000	180,000	177,000	145,000	159,000
600	10,000	61,000	160,000	124,000	116,000	94,000	171,000	164,000	177,000	141,000	154,000
800		58,000	138,000	105,000	106,000	86,000	153,000	157,000	158,000	138,000	148,000
1000		53,000	94,000	73,000	91,000	73,000	108,000	99,000	119,000	131,000	140,000
1200									74,000	103,500	120,000
1300										86,000	113,000
1500											52,000

TABLE III — Coefficients of Thermal Expansion, in./in./°F X 10^{-6}

Material	Temperature Range °F		
	70–400	70–800	70–1200
7075-T6	13.7	—	—
321 (Ann.)	9.4	9.9	10.7
4140	7.0	7.7	8.1
410 (Ann.)	5.5	6.0	6.5
6AL-4V (Ann.)	4.8	5.1	5.3
17-7PH	6.0	6.3	6.7
17-4PH	6.2	6.5	6.9
422 Modified	5.8	6.3	6.8
A-286	9.4	9.6	9.9
Inconel X	7.7	8.0	8.4



Procedure for bolt-relaxation testing.
(A) Bolt length before assembly. (B) Locknut tightened against sleeve makes bolt elongate under stress computed at 90,000 psi. (C) Bolted assembly subjected to high temperature for 100 hr—no change in elongation. (D) After cooling and disassembly at room temperature, free length of bolt is now greater than original because bolt tension relaxed to 40,000 psi during exposure to high temperature.

though creep rate of the steel accelerates above 800 F.

Above 900 F . . .

Recommended structural materials for temperatures up to 1300 F are the super alloys A286 and Inconel X. In general, as the temperature increases, the strength margin of Inconel X above A286 increases also. Because of high loss in ductility at this range, 422M is not generally specified.

PROPERTIES OF BOLTS AT HI-TEMP

Many of the structural materials in Table I can also be used for bolts. However, most data are established on smooth, round test specimens and it does not necessarily follow that the bolts will meet the material performance values in every case. Some of the factors affecting bolt strength are:

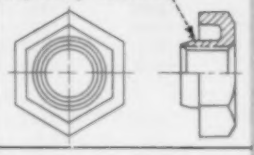
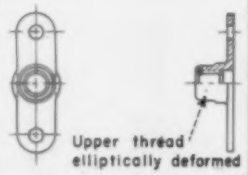
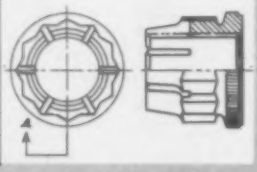
Notch Sensitivity . . . Results of tests show that in many cases (contrary to popular belief) the notched strength of a material is greater than the smooth strength. For example, typical stress-rupture properties of A286 at 1200 F and 65,000 psi for standard smooth and notched specimens are 72 hours and 216 hours respectively. Curves of load vs time are not necessarily parallel. They will actually cross each other in some materials. But in still others, the smooth-specimen strength is always greater. For design purposes, notch effect at high temperatures cannot be predicted. It should be based on test results only.

Size Effect . . . Tests show that, even at room temperature, fasteners with smaller diameters will develop greater unit strength than the larger diameters because of thread proportions in relation to bolt diameters, and the stress-intensity patterns across the threaded section. Properties such as tensile, stress-rupture, and relaxation strength also vary with bolt diameter.

Coefficient of Expansion . . . This rate varies with temperature range, Table III. When choosing bolt material, coefficients between bolt and structure should be as close as possible. A bolt that expands more than the structure will reduce the clamping force. If the structure expands more rapidly, the bolt will be overloaded and this can accelerate the relaxation of nut and bolt. It also can cause the joint to loosen while returning to room temperature.

For example, assume that a 303 stainless-steel bolt and nut are used to fasten a 431 stainless structure (coefficients of expansion are 10.1 x 10^{-6} and 6.8 x 10^{-6},

Table IV – Lock Nuts Used in Tests

Type	Description	Upper thread elliptically deformed
A	Hexagonal nut, low height with elliptical locking device	
B	Two-lug anchor	
C	Two-lug counter-bored anchor (shown)	
D	Two-lug floating anchor (all elliptically deformed)	Upper thread elliptically deformed
E	Double-hexagonal with slotted-beam locking device	
F	Same as E but with elliptical locking device	

respectively). The bolt has a ¾-in. grip length and is tightened to 90,000 psi. The bolt will elongate

$$(90{,}000)\ (\tfrac{3}{4})/(29 \times 10^{6}) = 0.0023 \text{ in.}$$

If the temperature is increased 900 F, the bolt will expand $10.1 \times 10^{-6} \times 900 \times \frac{3}{4} = 0.0069$ in. and the structure will expand 0.0046 in. The differential expansion is then 0.0023 in. Thus the bolt will have no load at operating temperature and the joint will be loose.

Reversing the materials to employ a 431 bolt with a 303 structure results in a bolt loading of about 180,000 psi. The nut and bolt will relax because the 431 material cannot maintain this load at the elevated temperature. The result is a loose joint when the assembly cools back to room temperature.

Stress Rupture . . . Three variables–load, time, temperature–are necessary to define this factor: the maximum static strength of the metal for an arbitrary period of time at elevated temperature. For example, from Table II, a test bar made of 7075–T6 and subjected to 200 F may fail after 100 hrs if the load is 65,000 psi. At 300 F and 100 hrs the same bar may fail at 41,000 psi. Stress rupture is most commonly rated at 100, 1,000, and 10,000-hour tests.

Relaxation is the most important factor in designing for maximum clamping force and retention of locking torque. It is a special case of creep that occurs particularly in bolts and nuts. Creep rates are obtained under constant load; but in a bolted member, the load begins to diminish as creep (or bolt elongation) occurs. The loss in tension in the bolted member is called relaxation.

To obtain relaxation data, the specimen is loaded and its initial deflection measured. This deflection is converted to bolt stress. The specimen is then subjected to temperature and, as the specimen relaxes, the initial load is reduced to keep the initial deflection constant. The specimen will relax rapidly at first, then settle to an almost constant rate. This test procedure (see illustration) is called a step-down relaxation test and, in effect, is a creep test with variable creep rate and constant specimen length.

Relaxation tests on locknuts are conducted with specific structural materials so that the effect of the expansion rates of the nut, bolt and structure are included. For optimum design of a bolted assembly, relaxation should be held minimum to obtain a constant clamping force.

HI-TEMP BOLT MATERIALS

If titanium alloy is chosen as the structural material for operating temperatures between 400 to 800 F, the obvious choice for bolts is the same material. Other compatible materials are 422M, 17-7PH and 17-4PH.

For temperatures up to 900 F, 422M has been established in many applications as the structure material and optimum choice for bolts. As a second possibility, titanium bolts can be considered on the basis of their high strength-weight ratio.

From 900 to 1200 F, two excellent structural materials are A286 and Inconel X. Both materials have similar coefficients of expansion, so choice of bolting materials is simplified–either can be employed interchangeably.

TIGHTNESS OF THE NUT

The use of high-temperature bolts that have all thread dimensions reduced 0.003 in. has been standardized almost universally for all temperatures above 550 F. Close-fitting Class 3 threads on both nut and bolt would cause galling at high temperatures, especially if the bolt had expanded more than the nut. Also it might be impossible to disassemble the parts if oxidation of either the nut or bolt material occurred.

EVALUATING LOCKNUTS

Nut properties at elevated temperatures depend not only on material but also on shape and type of locking device. Six types of locknuts, Table IV, were recently evaluated at Esna's research laboratories. Tests on other popular locknuts are being planned. The nuts employ either elliptically-deformed threads or the solid-beam principal for the locking device. Results from two series of tests at various temperature levels are listed: Table V gives stress-rupture strength; Table VI, relaxation characteristics.

Stress-rupture data give the maximum load and the number of hours that the nut (or bolt) can take at a specific temperature, without failing. Loads are converted into bolt stress. The tests also show that the stress-rupture strength of a material can predict the stress-rupture strength of a locknut or bolt–up to 1000

TABLE V — Stress-rupture

Temp., °F	Locknut Description			Bolt Material	Load		Type of Failure	Time, hr
	Type	Size	Material		lb.	1000 psi		
550	A	1/4—28	C-1045	SAE 8740	4560	140	Bolt	100
	B	1/4—28	305	SAE 8740	4890	150	Bolt	100
	C	1/4—28	C-1045	SAE 8740	4560	140	Nut	100
	C	1/4—28	C-1045	SAE 8740	2930	90	None	100
	D	1/4—28	C-1045	SAE 8740	4238	130	Nut	100
800	C	1/4—28	A286	17–4PH	4706	144	None	162
	C	1/4—28	A286	17–4PH	5060	155	Bolt	184
	C	1/4—28	A286	17–4PH	5380	165	Bolt	53
	F	5/16—24	17–4PH	17–4PH	3910	120	Bolt	115
900	A	1/4—28	A286	Inconel X	4240	130	Bolt	155
	C	1/4—28	A286	A286	3710	117	None	163
	C	1/4—28	A286	A286	4110	130	Bolt	21
	D	1/4—28	A286	A286	3805	120	Bolt	159
	B	1/4—28	A286	AMS 6304	3438	108	Bolt	319
	B	1/4—28	A286	AMS 6304	4080	129	Bolt	27
	B	1/4—28	A286	A286	4080	129	Bolt	25
	F	1/4—28	A286	A286	4110	130	Bolt	46
1000	A	1/4—28	A286	A286	3470	110	Bolt	70
	C	1/4—28	A286	A286	3010	95	Bolt	81
	D	1/4—28	A286	A286	3010	95	Nut	131
	D	1/4—28	A286	A286	3140	99	Nut	57
1100	C	1/4—28	A286	A286	2840	90	Bolt	19
	D	1/4—28	A286	A286	2480	75	Nut	7
1200	A	1/4—28	A286	A286	1710	54	Nut	61
	C	1/4—28	A286	A286	1710	54	Nut	115
	C	1/4—28	A286	A286	2000	63	Nut	29
	D	1/4—28	A286	A286	1710	54	Nut	34
	E	1/4—28	A286	A286	2220	70	Bolt	44
	E	3/8—24	A286	A286	5480	68	Bolt	66
	E	1/2—20	A286	A286	9981	63	Bolt	65
	E	1/4—28	347FM	A286	2130	67	Bolt	105
1300	E	1/4—28	A286	A286	1308	41	Bolt	142.3
	E	1/4—28	A286	Inconel X	1469	45	Bolt	172
	E	1/4—28	A286	Inconel X	1630	50	Bolt	71

F. For example, if these test results are compared with the values in Table I, it is seen that the tests for 800 and 900 F are equal to or greater than the smooth-specimen material properties. At 1000 F, the data are nearly equal, and at 1100 and 1200 F the materials properties exceed the fastened test results. Reason for this is that at the higher temperatures, the nuts yield significantly and the thread loading on the bolt will not be as uniform as at lower temperatures.

The relaxation-test results will help predict the permanent loss in tension that occurs for a given condition. These data also show that by carefully choosing combination of materials the effect of thermal expansion can be tolerated.

REUSABILITY AFTER TEMPERATURE

The same series of locknuts were tightened to 90,000 psi at room temperature and, after exposure to various temperatures for 100 hr, subjected to torque tests. Up to 900 F, all nuts were found reusable at least 15 times (using the torque test specified in the government specification MIL-N-25027).

At 1200 F, however, almost all locknuts had practically no reusability. This was because the locking element had relaxed to the point where pressure against the bolt threads almost vanished.

FUTURE TRENDS

As operating temperatures exceed 1300 F, several basic problems occur. The majority of materials for use above 1300 F contain increasing amounts of nickel and cobalt. The materials are expensive and require slower machining speeds, resulting in high-cost nuts and bolts. To minimize machining difficulties both nuts and bolts can be made by investment casting methods. This approach will require compromises; the materials may

TABLE VI — 100-hr Relaxation

Temp., °F	Locknut Description			Bolt Material	Structure Material	Load, 1000 psi	
	Type	Size	Material			Initial	Final
550	A	1/4—28	C-1045	SAE 8740	Medium	93	68
	A	5/16—24	C-1045	SAE 8740	Carbon	90	64
	C	1/4—28	C-1045	SAE 8740	Steel	90	68
	D	1/4—28	C-1045	SAE 8740		93	56
	D	5/16—24	C-1045	SAE 8740		93	71
800	A	1/4—28	17-4PH	17-4PH	17-4PH	90	75
	A	1/4—28	17-4PH	Titanium	Titanium	92	37
	A	5/16—24	17-4PH	Titanium	Titanium	93	46
	A	3/8—24	17-4PH	17-4PH	17-4PH	88	77
	A	1/4—28	A286	17-4PH	17-4PH	88	75
	A	1/4—28	A286	Titanium	Titanium	92	40
	C	1/4—28	A286	422M	Titanium	90	63
	D	1/4—28	A286	17-4PH	17-4PH	90	73
	B	1/4—28	305	17-4PH	17-4PH	91	70
	B	1/4—28	305	AMS 6304	AMS 6304	90	58
	B	1/4—28	305	A286	A286	90	34
	E	1/4—28	303	17-4PH	17-4PH	92	73
	E	1/4—28	6304	17-4PH	17-4PH	93	77
	E	3/8—24	303	17-4PH	17-4PH	90	72
	F	1/4—28	17-4PH	17-4PH	17-4PH	160	132
	F	1/4—28	17-4PH	Titanium	Titanium	90	41
900	A	1/4—28	A-286	Inconel X	Inconel X	90	68
	A	1/4—28	A-286	AMS 6304	AMS 6304	90	57
	A	1/4—28	17-4PH	17-4PH	17-4PH	90	56
	D	1/4—28	A-286	A286	A286	87	47
	D	1/4—28	A-286	422M	Titanium	93	49
	C	1/4—28	A-286	A286	A286	88	39
	C	1/4—28	A-286	422M	Titanium	93	47
1200	C	1/4—28	A-286	A286	A286	87	31
	E	1/4—28	A-286	A286	A286	80	38
	E	5/16—24	A-286	A286	A286	80	50
	E	3/8—24	A-286	A286	A286	80	45
1300	E	5/16—24	A-286	A286	A286	90	40
	E	5/16—24	303	A286	A286	90	20

have lower strength and ductility, and less accurate thread dimensions.

Temperatures above 1300 F can also necessitate fits looser than the present concept of 0.003-in. relieved threads. There will be need for better platings or protective finishes because silver-plated bolts and nuts have a tendency to bond together above 1300 F. Tests are being conducted on other metallic platings but with few good results to date. More promising is the investigation on ceramic coatings and lubricants to protect the metal.

EDITOR'S NOTE: Other recent articles dealing with properties, stability and fabrication of materials for high-temperature service:

"High Temperature Stainless," Apr '57, p 135, discusses eight alloys for temperatures of 600 to 1400 F.

"New Nickel-Free Stainless," Dec '56 p 151, presents high-temperature data on an austenitic steel with nickel replaced by manganese and nitrogen.

"Metals at Elevated Temperatures," Oct '56, p 160, discusses the influence of high temperature on a wide variety of metal properties and shows how to predict long-time behaviour from short-time data.

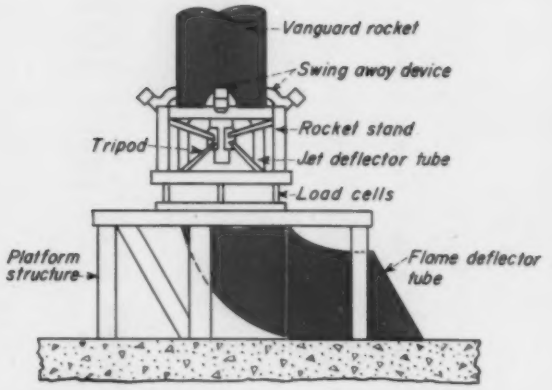
IN A COMING ISSUE . . .

COMPRESSION CREEP

High temperature brings special design problems when parts are stressed in compression—problems different from those when components are in tension. A coming article will explain these differences.

You Hold a ROCKET by Its Tail

Holding down a 72-ft rocket against a 27,000-lb engine thrust, balancing it in a vertical position, and releasing all hold-down devices without disturbing the rocket's balance, are typical functions of the launching platform for Vanguard. Engineers at the Martin Co. and at Loewy-Hydropress, the subcontractor that built and installed the platform, devised a hold-down mechanism that clamps onto the gimbal ring of the extended first-stage-engine nozzle. It literally holds the rocket by the tail. The launching platform is unusual because it can both static-test and launch the rocket. Several three-stage Vanguard vehicles will attempt to place satellites in orbits around the earth in support of US participation in IGY.



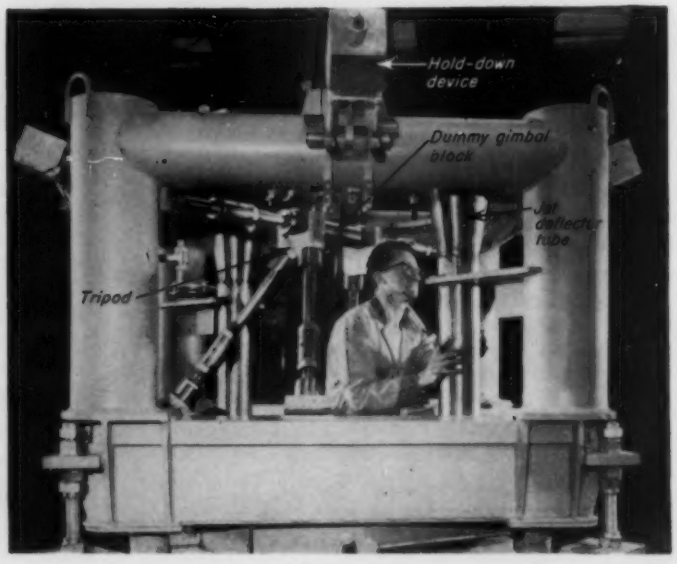
PLATFORM STRUCTURE HOLDS WORKING DECK THAT SUPPORTS ROCKET STAND.

Inside this structure is a flame deflector tube to direct rocket exhaust out over a concrete pad. To avoid subjecting this carbon-steel tube to the 4000 F gases, high-pressure water is sprayed through hundreds of holes drilled through its walls. Deflector tube is isolated from rest of structure so its vibrations won't affect readings of the SR-4 strain-gage load cell system that measures thrust and weighs rocket vehicle.

Exhaust blast is diverted away from the structure during static firing tests, but the platform must withstand the hot gases for the 5-sec interval of the actual launching. Emergency fog nozzles extend over the working platform to release a high-pressure mist spray if fire occurs. Emergency eyewash stands and a safety shower are provided for personnel. Structure is about 20 ft square.

ROCKET SUPPORT STAND . . .

is 6½-ft-square structure of 8- and 12-in. dia carbon-steel pipe and structural steel, enables the launching platform to serve as static-testing facility. Testing procedure requires rocket and fuel to be weighed and thrust measured so engine performance can be evaluated. Before a launching attempt, the rocket vehicle must demonstrate its ability to develop required thrust. Two stainless-steel jet deflector tubes inside the rocket stand catch high-temperature (800 F) steam blasts from the rocket's small stabilizing jets and carry them into the flame-deflector tube. These jets are servo-controlled to counteract lateral motion or roll that might develop as the rocket takes off. Jet deflector tubes are made of 347 stainless steel. Four swing-away retaining devices are on cross tubes between the stand's vertical pillars. These are the devices holding down the rocket structure and bracing it in a vertical position for firing. They swing back to clear the gimballed engine as it passes by. Tripod structures within the stand grip gimbal ring of extended engine nozzle and transmit thrust loads to the frame.



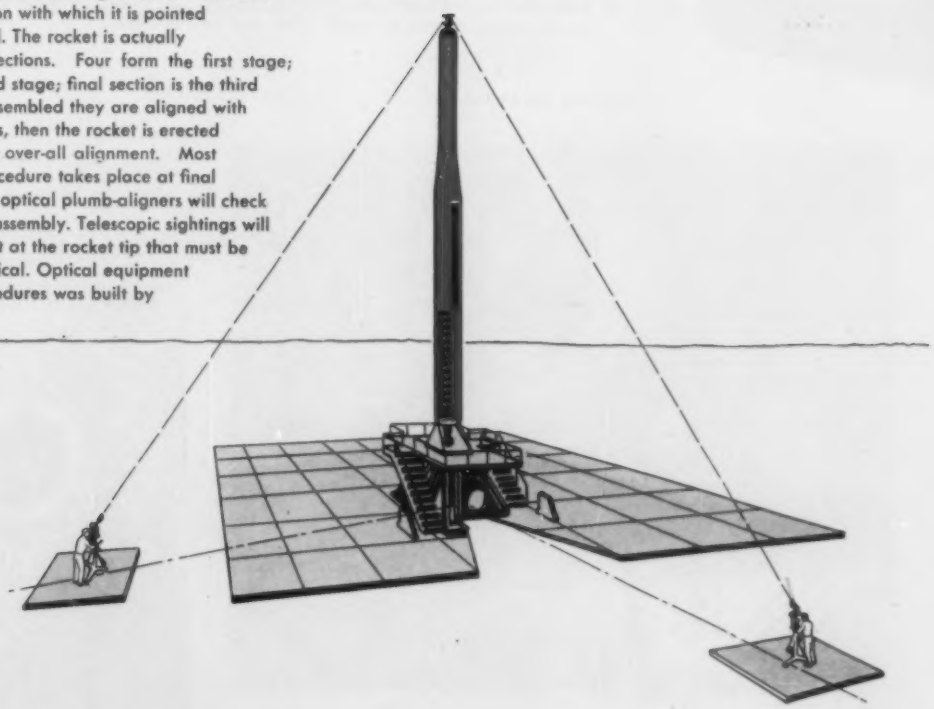
IN NEW PRODUCTS

TRIPODS ARE MADE OF 300 AND 400 SERIES STAINLESS STEELS . . .

They absorb thrust while swing-away devices hold rocket, and prevent thrust forces from overstressing rocket structure during static firing tests. Tripods are removed from stand before the rocket is launched. All stand components are designed to withstand 5000-F temperatures for short periods. During 5-sec period predicted for rocket to clear platform when fired, stand structure is expected to reach a temperature of 1000 F.

HOW ACCURATELY THE SATELLITE IS PLACED IN ITS ORBIT . . .

depends to a critical degree on straightness of assembled rocket as well as precision with which it is pointed vertically when launched. The rocket is actually an assembly of eight sections. Four form the first stage; three sections, the second stage; final section is the third stage. As sections are assembled they are aligned with special tooling telescopes, then the rocket is erected in a test tower to check over-all alignment. Most elaborate alignment procedure takes place at final erection, however, when optical plumb-aligners will check straightness of the final assembly. Telescopic sightings will also be made on a target at the rocket tip that must be within ¼ in. of true vertical. Optical equipment used for alignment procedures was built by Keuffel and Esser Co.

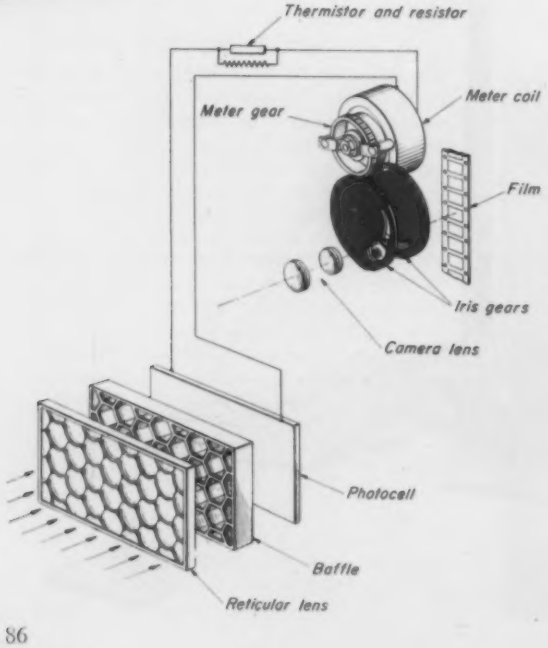


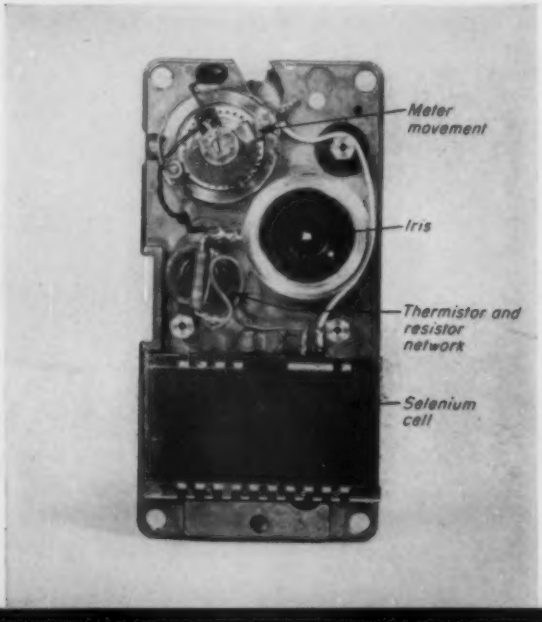
Electric current generated by a selenium photocell is the only power required to adjust the iris of this movie camera. Developed by the Bell and Howell Co., Chicago, Ill., it is the first 8-mm movie camera to have automatic exposure control. Key element of the control is a low-friction iris mechanism positioned by a meter movement.

Solar Power Adjusts Camera Iris

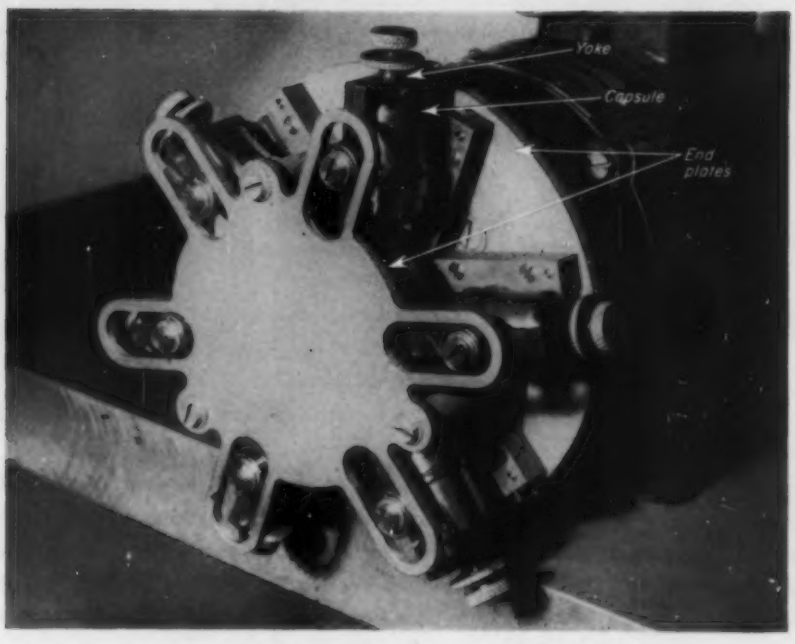
AUTOMATIC EXPOSURE CONTROL . . .

is built into the plate that serves as lens mount. At the bottom of the plate, beneath the camera lens, is a selenium photocell. It is protected by a honeycomb baffle and reticular lens designed so field of photocell matches angular coverage of the camera's f/1.9 universal focus lens. Current generated by the photocell positions a meter movement geared to the two iris disks, which rotate to determine size of lens aperture. Disks are synchronized to compensate for their individual inertia unbalance so aperture will not change when camera is moved. They are on tungsten pivots riding in conical Armaloy bearings and are moved through the range from f/1.9 to f/16 in less than 1 sec by the 50-microamp meter movement. A thermistor and resistor network, in series with the meter movement, compensates for temperature characteristics of the selenium photocell. Meter pointer indicates "f" stops on a calibrated, transparent plastic cover. A knob below this cover serves as a manual control that can override the automatic control. A flag on the meter pointer blocks the light path to a tinted prism in the viewfinder so it appears black when too little light is available for taking pictures.





High-speed Ball Mill

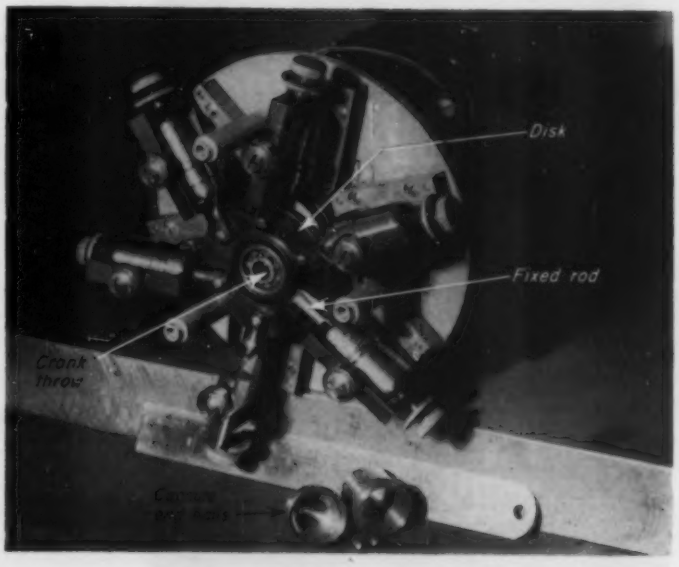


Radial grinding capsules driven from a common crank, and running at speeds up to 2000 rpm, compound mixtures for the British National Coal Board's research laboratory at Stoke Orchard, Gloucestershire. Crank rotation oscillates and reciprocates capsules to grind particles as small as 5 microns.

MACHINE GRINDS POTASSIUM BROMIDE WITH COAL . . .

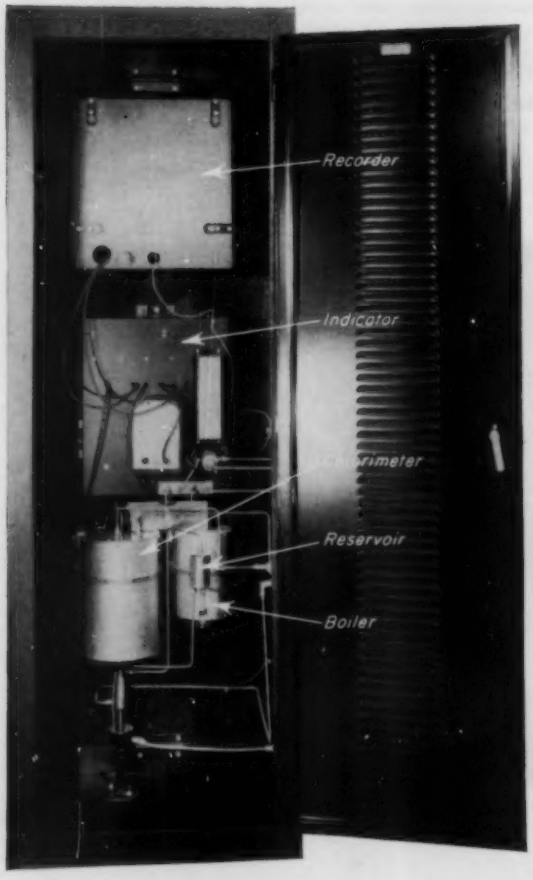
to form disks used for infra-red analysis. With this design, it is possible to grind small quantities of material in less time and with better compounding than obtained with previously available machines. Also, this machine is more compact. Each capsule holds 100 g of compound and two 3/32-in. dia soft-steel balls.

Capsules are clamped between cones and sockets inside yokes built into connecting rods. One rod is fixed on the disk that rides crank throw, and remaining rods pivot in ball bearings mounted in this disk. Ball bearing lugs on each side of the yokes ride guide slots in end plates. Product consistency is not affected by variations in oscillating motions of capsules.



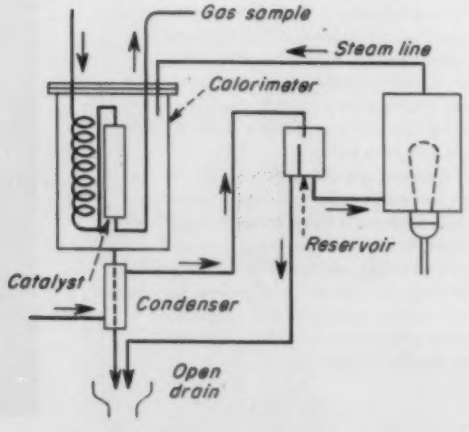
Heated Catalyst for Gas Analyzer

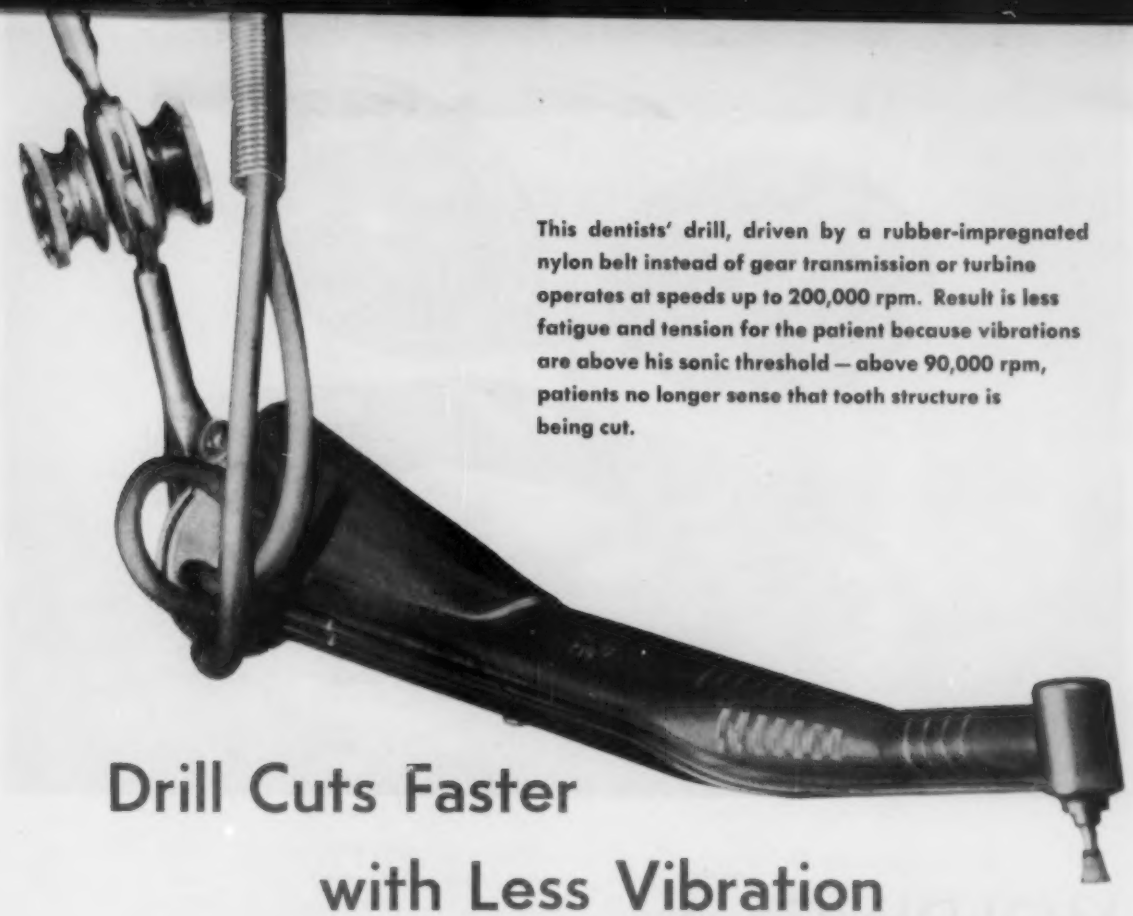
In instruments made by Baker and Co., EastNewark, N. J., oxygen is detected by introducing a controlled amount of hydrogen into the sample and passing the mixture through a platinum catalyst. Previously, any carbon monoxide in the sample made the detection system unworkable. Now, by heating sample and catalyst in a steam calorimeter, accurate analyses are possible when carbon monoxide is present.



WHEN GAS SAMPLE PASSES THROUGH CATALYST . . .

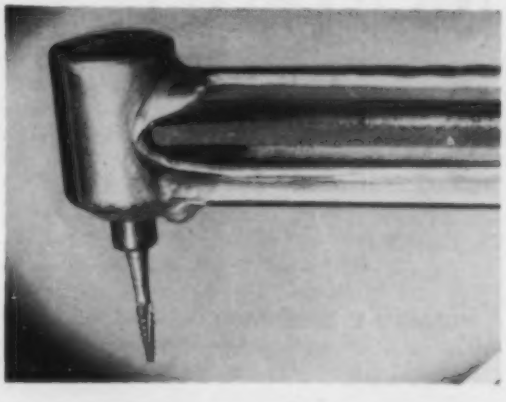
the hydrogen combines with whatever oxygen is present and this chemical reaction raises the sample's temperature. Thermopiles positioned where the gases enter and leave the catalyst detect the temperature rise and transmit a signal to a calibrated recorder. Present instrument can detect 2 to 200 ppm of oxygen in the presence of up to 3% of carbon monoxide. Catalyst and gas sample are held at 100 C in a steam calorimeter. Steam is generated in an electrically heated boiler, passed into the calorimeter, and condensed at atmospheric pressure. A weir in the water supply reservoir controls water level in the boiler.

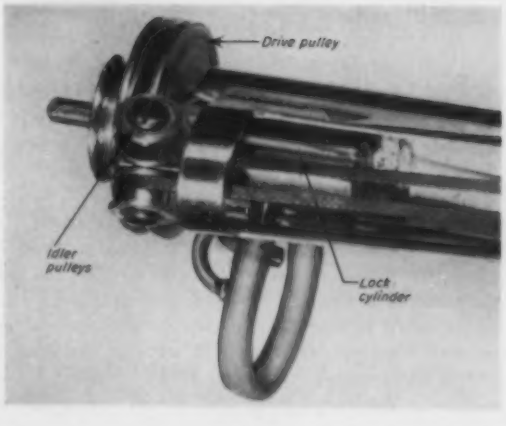




This dentists' drill, driven by a rubber-impregnated nylon belt instead of gear transmission or turbine operates at speeds up to 200,000 rpm. Result is less fatigue and tension for the patient because vibrations are above his sonic threshold — above 90,000 rpm, patients no longer sense that tooth structure is being cut.

Drill Cuts Faster with Less Vibration



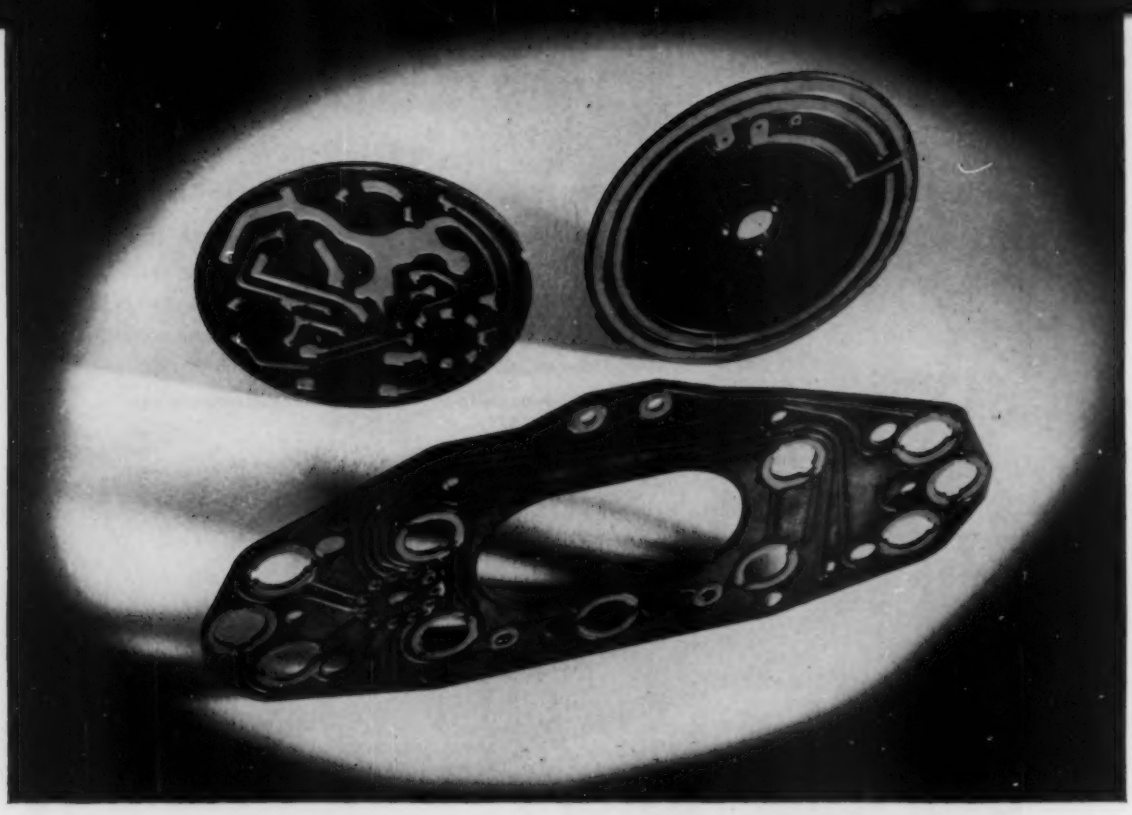


BELTS DELIVER POSITIVE DRIVE . . .

with a 10:1 speed increase. First speed increase is 2:1 at stepped pulley on input end; an additional 5:1 occurs in belt drive within the handpiece. Unlike air-turbine drives, spindle speed does not decrease when cutting burr is under load. If stall load is applied, slippage occurs in belt drive between handpiece and engine. Reduced vibration and absence of a lubrication problem are advantages over using gears.

Pulleys and spindle are supported on sealed, miniature ball bearings. An air cylinder locks the drive pulley to prevent spindle rotation unless air is supplied to handpiece. Capillary tubes carry air inside spindle head and to external spray-jet adjacent to burr. Air delivered inside spindle head escapes around chuck to cool burr and prevent saliva or debris from entering drill. Result is a handpiece that does not require disassembly for cleaning after use.

Invented by Richard Page, a practising dentist of Chappaqua, N. Y., drill is result of over 10 years' research. Production model, called the Page-Chayes handpiece, is manufactured by Chayes Dental Instrument Corp., New York City.



MOLDING moves in on PRINTED CIRCUITS

NORMAN L. GREENMAN, *Manager of Planning*
Rogers Corp., Rogers, Conn.

This process permits built-in wiring with heavier copper and other metal stocks that will carry larger currents. It offers mass-production economies along with design specialties like multilevel circuits, three-dimensional design and choice of wiring-board shapes, but has some limitations too.

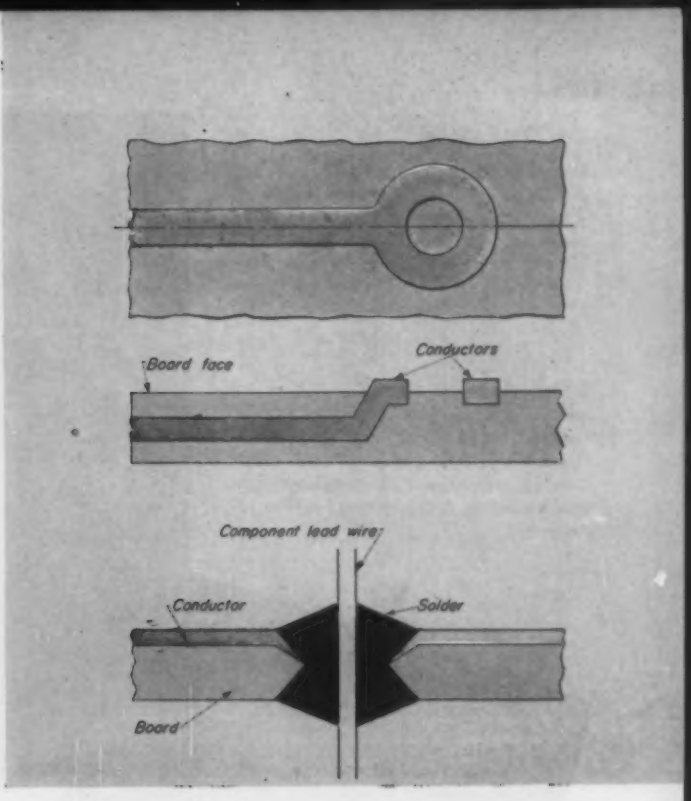
Usefulness of printed circuits has been broadened by a technique adapted for producing them. It is the molding process, familiar in other fields but a new aid for the designer who wants to move electricity over built-in wiring.

This rival to etched or electrodeposited circuits is not only competitive in price. The molding method also allows the incorporation of protected conductors, three-dimensional design and increased current capacity. One direct result is that printed circuits can now be used in electric ranges, motor controls, washing machines and automobiles.

Because the metal pattern for the circuits is cut from foil stock mechanically, the use of much heavier metal is possible. Already conductors have been cut from copper 0.020 in. thick, weighing about 15 oz/sq ft (15-oz stock.) This contrasts with etched circuits generally produced from copper stock only 0.00135 or 0.0027 in. thick, weighing 1 or 2 oz/sq ft.

The structure of molded assemblies allows maximum working temperatures listed by Underwriters' Laboratories at 238 F. By contrast the maximum specified for laminated-etched assemblies is 157 F.

An examination of the two methods shows why molding allows successful handling of thicker stock, even though all printed circuits are basically similar—



Sinking conductor . . .
into the board base protects against accidental shorting and wear. Molding also permits raising parts of conductor pattern to facilitate contact with other components.

Tapered hole . . .
formed by molding makes it easier to insert component lead wire. With a double taper, solder is anchored so firmly that lead wire cannot be pulled out accidentally.

conductive patterns bonded to an insulating baseboard.

Etched circuits are made by laminating metal foil to the base, printing the desired pattern on the metal surface with an acid-resisting ink, then etching away unprotected metal. But the acid undercuts edges of the pattern, where metal is unprotected, as it bites into the metal sheet. This undercut, negligible when the metal is thin, increases with thicker metal and weakens the adhesive bond by reducing contact area between conductors and base. Also, because an etched circuit is normally raised above the insulating board, undercut edges provide points for sharp tools to catch and lift or tear the conductor.

By contrast, for a molded circuit the pattern is cut mechanically from the desired sheet. This produces a clean edge without undercuts and permits much heavier metal foil.

TWO WAYS TO CUT PATTERN

The basic method for cutting a conducting pattern from foils uses a single die to stamp the sheet against an uncured molding board. Pressure is sufficient to make the board yield under the die, shearing the metal at the same time that the pattern is tacked to the board. Excess metallic sheet is peeled off.

An alternate method interposes a female die or stripper-plate between metal sheet and board. As the press is closed, the male die cuts the pattern against the templet, then presses it against the board. Excess foil remains above the templet and can be removed mechanically when the press opens. This makes the process adaptable to completely mechanized operation.

For either method the metal is backed with a thermosetting adhesive. It forms a permanent bond between conductor and board when the assembly is cured.

THE MOLDING CYCLE

Another die, more often a matched dieset, is needed for the molding cycle. Performed with a compression-molding machine operating at about 3000 psi in 90 sec. or less, at 310 to 325 F, it bonds the conductors to the board, gives the board its final shape, and makes it rigid. Molding also forms a resin skin over the entire board. The skin acts as an effective seal over all edges and hole walls, reducing possibility of moisture absorption.

CIRCUIT DESIGN

Ability to produce shapes other than flat boards is one of the biggest assets of the process. Circuits have been produced experimentally on boards bent during molding.

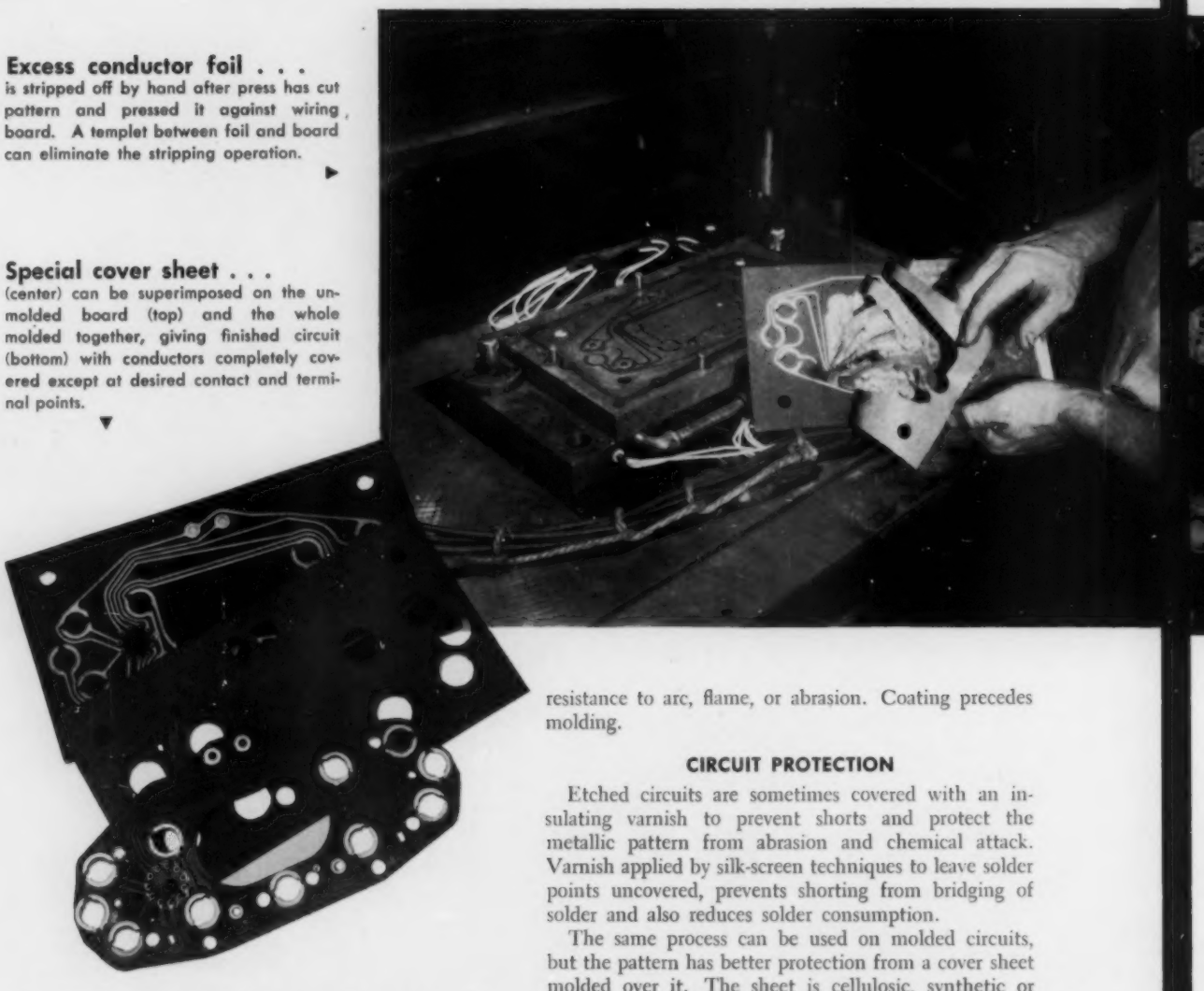
Already in production are boards with some sections raised above the board face to facilitate contact with other elements of the electrical circuit and other sections depressed into the board to protect them from wear and accidental shorting.

The process also allows molding the conducting inserts into the insulating base for terminals on both sides. Components can then be mounted on either or both sides of the board, without the added costs of plating the punched holes or soldering additional holes. Molding more than one circuit in the board, with conductors connecting the two, allow obvious advantages—the molded assembly can often replace two or more boards of the etched-circuit type.

Minimum recommended dimensions are $\frac{1}{16}$-in. width of conductors and $\frac{1}{16}$-in. spacing between them. These dimensions limit application of the process. Narrower conductors are difficult to shear accurately, especially if a templet is used; the trouble with closer spacing is an-

Excess conductor foil . . .
is stripped off by hand after press has cut pattern and pressed it against wiring board. A templet between foil and board can eliminate the stripping operation.

Special cover sheet . . .
(center) can be superimposed on the unmolded board (top) and the whole molded together, giving finished circuit (bottom) with conductors completely covered except at desired contact and terminal points.



other kind. It prevents sinking conductors into the board properly—by pulling down the intervening insulating islands.

CONDUCTOR MATERIALS

Either electrodeposited or rolled copper foil, printed circuit grade, is the material most often used. Others are foils of brass, aluminum, nickel, Nichrome, Inconel, stainless steel, nickel silver and tinned copper. Copper foils plated with rhodium, silver or nickel are least frequently chosen.

Two or more conductor materials can be incorporated in the same circuit, but each must be stamped separately. This requires additional tools and increases costs.

INSULATING BASE

Boards for the circuits are cut from moldable sheet materials generally made of cellulose fibers impregnated with phenolic resin. Sheets are available in grades that, when properly molded, will meet NEMA standards for laminates up through XXXP. The boards can be coated or modified to obtain special properties such as resistance to arc, flame, or abrasion. Coating precedes molding.

CIRCUIT PROTECTION

Etched circuits are sometimes covered with an insulating varnish to prevent shorts and protect the metallic pattern from abrasion and chemical attack. Varnish applied by silk-screen techniques to leave solder points uncovered, prevents shorting from bridging of solder and also reduces solder consumption.

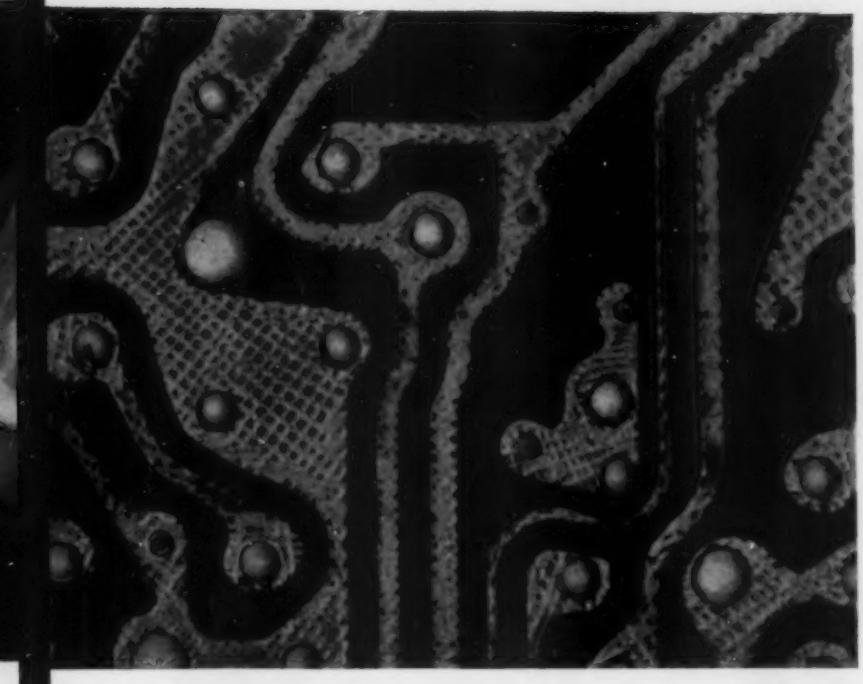
The same process can be used on molded circuits, but the pattern has better protection from a cover sheet molded over it. The sheet is cellulosic, synthetic or glass-fiber material impregnated with a resin compatible with the one in the insulating base, with punched holes at solder and other contact points, and is cut from light weight material compressed to about 0.003 in. in molding. Its thickness and resistance to abrasion and mechanical shock protects the conductors effectively. The sheet is bonded to the base by the molding process, producing a sandwich with the conductor as filler.

CONDUCTOR LEVEL

Molding dies can be made to emboss the insulating board so that the conducting pattern is flush with, below, or above the base plane of the board face. Depressed conductors are better protected against abrasion and shorting, even when a cover sheet is not used. Also, they are closer to the neutral axis or center of the board thickness; this results in reduced bowing and warping of the board from uneven expansion.

Raised conductors serve as contact points for built-in switches, or as connectors for special bulbs, fuses, resistors and plugs of various types.

Raising and depressing can be combined in the same



Embossing conductor . . . into the board strengthens adhesive bond between them. Here a transparent cover sheet permits viewing the effect of embossing on the pattern.

circuit. While most of the circuit is protected against shorting and can be shielded by a cover sheet, special sections can be raised, through holes in the cover sheet if necessary, to give special contacts with other elements of the assembly.

Thermosetting adhesives for cementing a conducting pattern to insulating board give a bond with peel-test strength of 10 to 20 lb/in. Embossing conductors into the board during molding, increases the contact area between conductor and board, resulting in increased total bond strength.

USEFUL HOLES

Holes or slots are molded in the boards for:

- Mounting components mechanically.
- Holding the board to other assemblies.
- Connecting pattern on one side to pattern on reverse side by subsequent eyeletting, electroplating or dip-soldering operations.
- Dip-soldering connections between component leads and the pattern.

Punching the holes the standard way would leave ragged edges weakening the board at such points. By molding them in, some material that would be punched out is forced into the area immediately surrounding the hole. This results in additional strength, allowing greater hole concentration. It also reduces moisture absorption. Holes as small as 0.020 in. can be molded.

Molding allows holes to be tapered or double tapered to insert components and lead wires more easily. When double-tapered holes are filled with solder metal, shape of solder on freezing, mechanically anchors component lead wires.

With molding, design shape isn't limited to standard flat boards. The process permits incorporating such items as stiffening ribs, reinforcements, bosses and terminal connector blocks. Multilayer circuits can be produced with perfect hole registry for assembly and for inserting wiring and component leads.

FABRICATION COST

Another advantage is that this process uses equipment normally found in most shops and useful for other work. Such equipment occupies a minimum of floor space and can be operated by unskilled or semiskilled personnel, and has high productivity. When production requirements are sufficiently large, mechanization of the process gives additional productivity.

If tooling costs are disregarded, molding is less costly than etching. Counting cost of necessary tools, break-even point between the processes is somewhere between 15,000 and 40,000 units, depending on complexity and size of circuit. Small-scale production is more economically done by etching and this is a serious limiting factor in situations where both processes can produce a satisfactory printed circuit.

EDITOR'S NOTE:

A comprehensive study, "Printed Wiring for Industrial Service," Aug '56, p 167, (available as a reprint), covers advantages and limitations of various types of printed wiring. Etched, plated, embossed and pressed wiring are compared. Properties of copper and silver conductors are discussed along with characteristics of phenolic, nylon, melamine, silicone, and epoxy insulating boards. Resistors, capacitors, switches, variable controls, connectors, and other components specifically designed for insertion into printed wiring are illustrated and a design roundup given.

Coming in Design Digest issue is an article on standing-wave soldering. For soldering on one side, this process has a high production rate accompanied by low heat, allowing the use of a lower-grade laminate.

shortcut for holding-magnet design

RICHARD A. SCHOLTEN
Design and Application Engineer
The Indiana Steel Products Co.

Here's a method, fast and accurate, that eliminates wading through complex equations. Instead, the magnet dimensions are obtained by high-school algebra in a simple three-step procedure using basic performance data presented here.

A unique labor saver is now available for designing holding magnets and the assemblies that incorporate them. Gone is the need to manipulate energy factors like gauss and oersted in circuit calculations involving triple-decker equations. The work is done with graphs and requires mathematics no harder than cubing a number, then taking its square root.

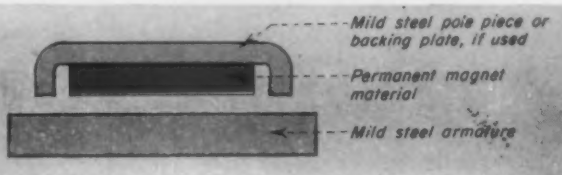
A comparison of configurations, Fig. 1, is the key to the method. It works because in most cases any magnet design with known performance can be used to predict the performance of any other magnet of the same material and geometric shape—regardless of size.

For example, a 0.01-lb magnet with 0.44-lb pull at 0.02-in. air gap can serve to predict that a 0.27-lb magnet of the same configuration but with 0.06-in. air gap will pull 3.92 lb.

Only three factors are needed for such quick and accurate design calculations—required pull, air gap, and geometric shape of the proposed magnet. This is because geometrically similar magnetic systems, Fig. 1, have similar magnetic properties. If air gap and each magnet dimension are multiplied by the same factor K, the new system will be geometrically similar and the pull force will vary directly as the area of the magnet-pole face.

Charts and tables on following pages provide the known performances required as starting points. Charts in Fig. 2 cover the 24 basic designs of holding mag-

Table 1—Nomenclature of Holding-magnet System



G	Air gap, measured from closest point of magnet assembly to surface of armature, in.
P	Pull for finite gap, lb
P_O	Pull for zero gap, lb
W	Weight of magnetic material in basic design, lb
W_T	Weight of basic magnet assembly (does not include armature), lb
W_N	Weight of magnetic material in new design, lb

nets, and the curves in Fig. 3 compare the relative performance of each so that the best design can be selected.

SELECTION OF MATERIAL

Specific steps in design procedure are described at the bottom of p. 100. First consideration is the material to be used, either for a simple magnet, or incorporated in mild-steel backing plates or pole pieces.

Both Alnico and ceramic permanent-magnet materials work in the majority of holding-magnet applications. Some differences in performance, physical characteristics and cost make one or another more favorable in specific cases. For example, barium-ferrite ceramic maintains its magnetic strength despite weakening influences like contact with other magnets or frequent pulling of the magnet from the steel armature. Alnico is more sensitive to demagnetizing influences, but has greater physical strength and is not so likely to chip as the brittle ceramic; however, protective non-magnetic plates may be used over ceramic magnets.

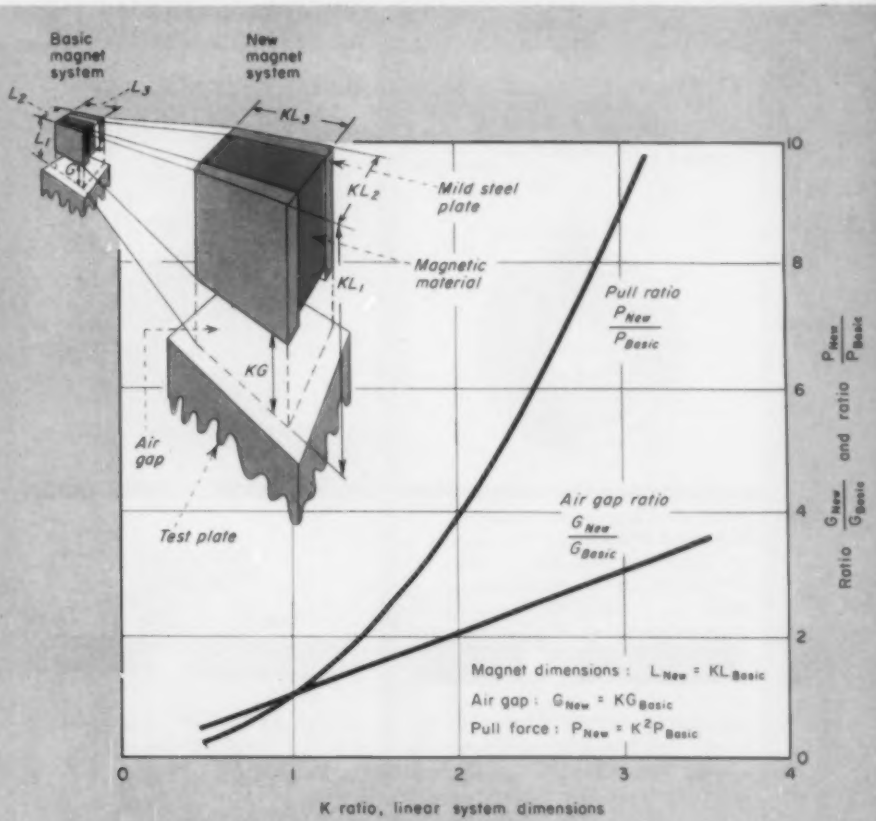
A ceramic magnet is usually cheaper except in the small sizes, where quantity-produced sintered Alnico magnets are competitive. Cast Alnicos do not have the clean surface appearance and dimensional accuracy of pressed, sintered Alnicos, or the good appearance of barium ferrites, but any magnet can be ground to accurate dimensions where necessary. Barium-ferrite has poor tolerances due to high shrinkage during processing.

Both ceramic and cast-Alnico magnets can be made in large sizes. Two barium-ferrite ceramic types are available: non-oriented and oriented. The former type is pressed without specifically aligning the magnet grain or molecular structure; the latter is oriented in the direction of pressing. Both are efficient in short magnetic lengths, but if too short, they warp during manufacture. All barium-ferrite magnets are pressed, hence require expensive tooling.

Non-oriented barium-ferrite material costs less in some applications because plain or counterbored holes can be provided in the direction of pressing at no extra cost. Also, it can be magnetized before final assembly without loss of strength. The oriented material must be magnetized after assembly for best properties, cannot have counterbored holes, and must have at least 2 sq-in. area and ¼-in. rounded corners; but the resulting pull is greater for the same weight of material.

Alnico V material is oriented and can be cast or sintered. Cast Alnico V will meet most pull requirements with less weight than sintered Alnico V. The latter is useful where the need is for a small magnet (max 0.05 lb) with best physical properties and high performance. Sintered Alnico II is not oriented and can be magnetized without regard for direction of heat

(Continued on page 99)



1 Pull-force relationship between geometrically similar systems consisting of magnet, backing plate or pole pieces, and air gap. New system is made similar to the basic one by multiplying each dimension by ratio K. Pull force will be proportional to K^2. A single graph of this type gives pull vs air gap relationship for geometrically similar magnets.

BARIUM FERRITE **non-oriented**

24 BASIC DESIGNS for HOLDING MAGNETS

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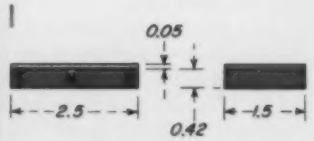

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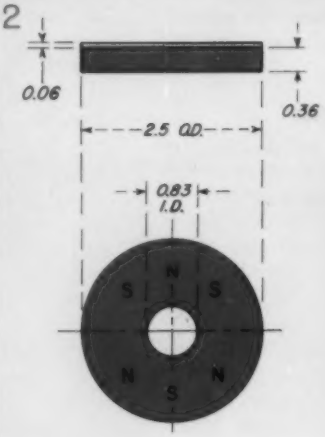

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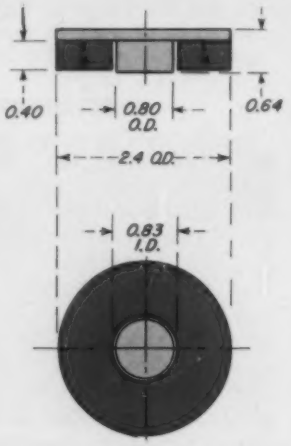

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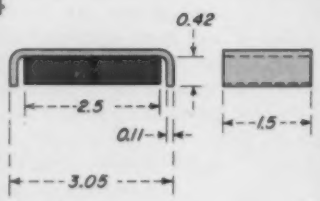

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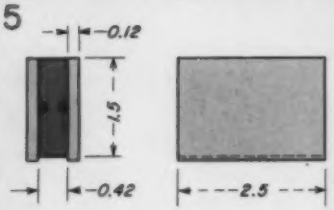

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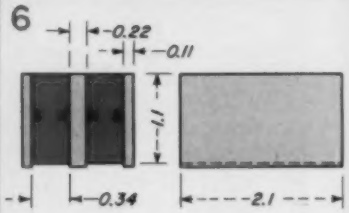

oriented

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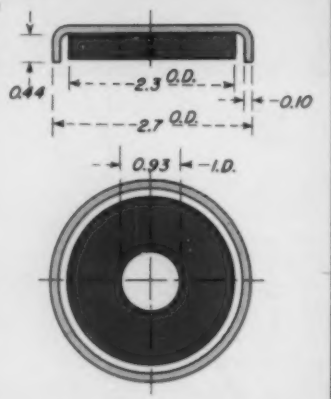

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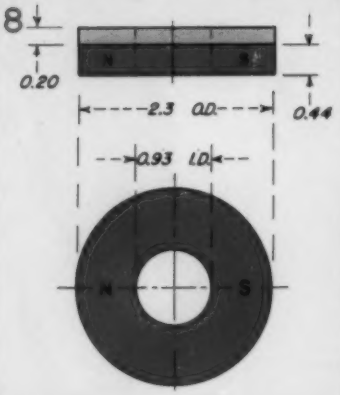

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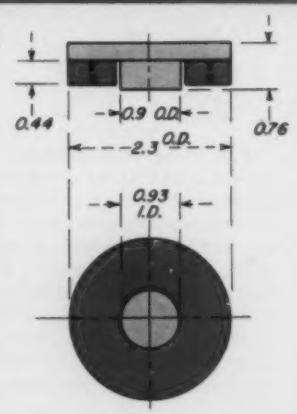

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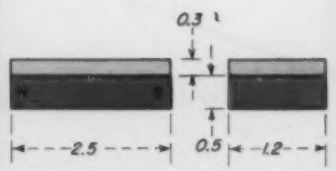

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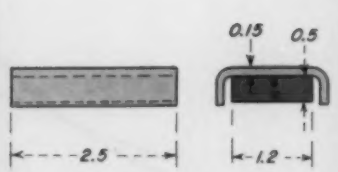

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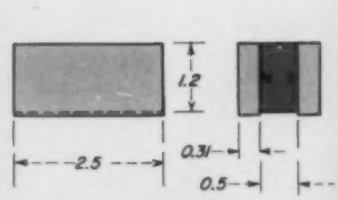

ALNICO

cast

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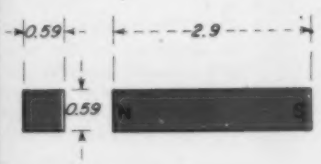

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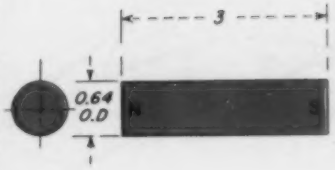

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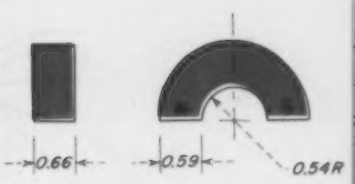

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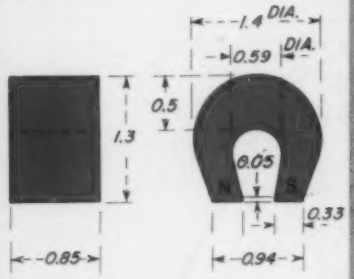

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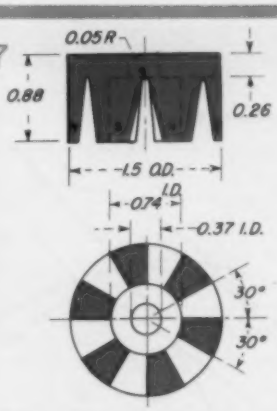

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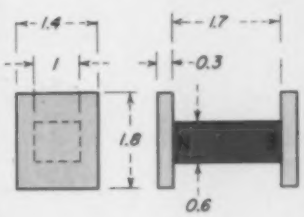

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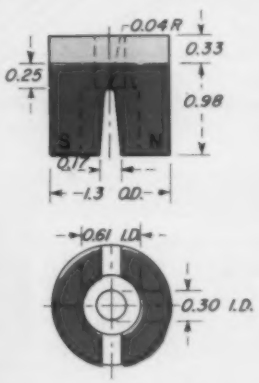

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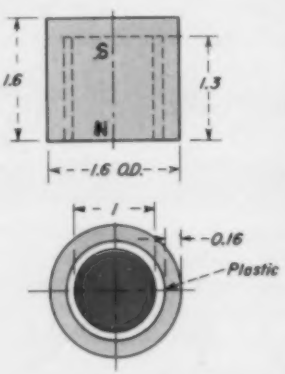

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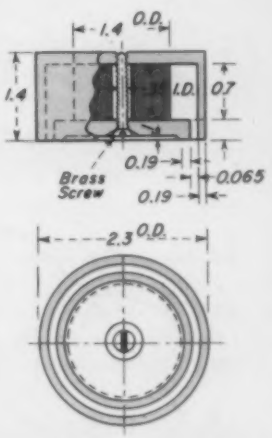

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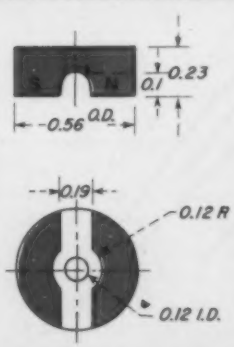

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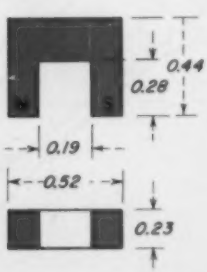
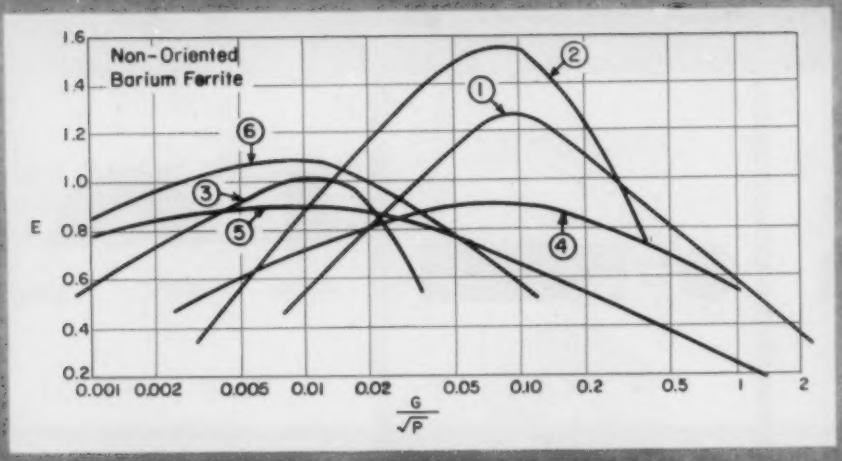
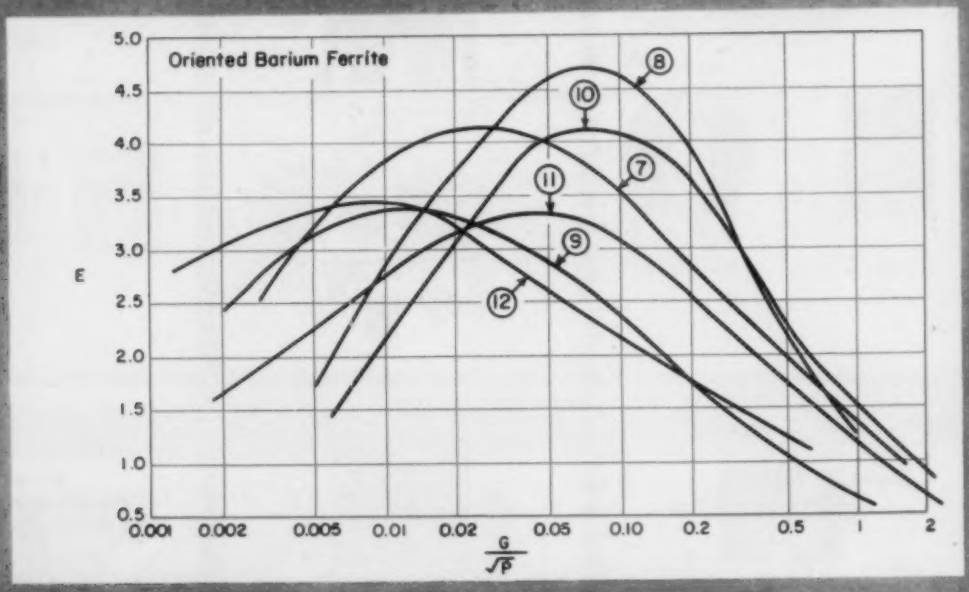
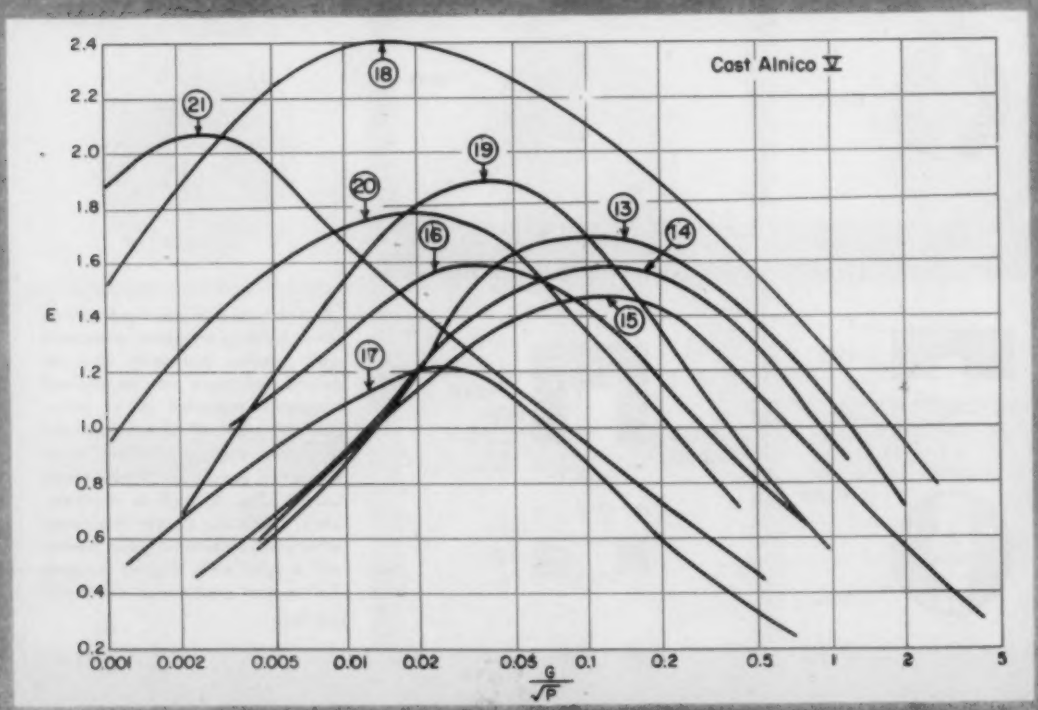


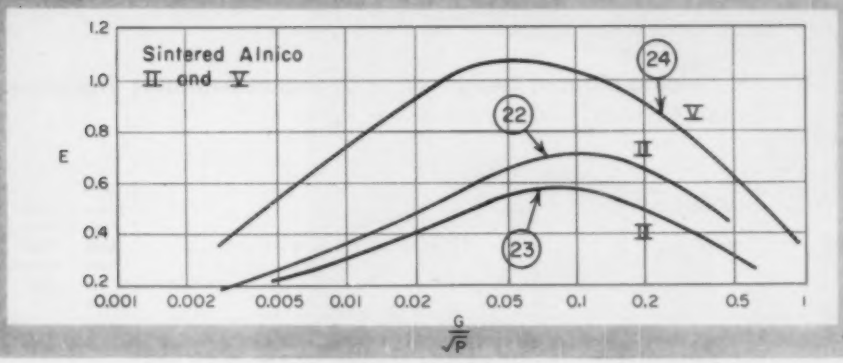
2 From these configurations other holding magnets, geometrically similar but with any required pull force, can be derived. Magnetic material is in color, steel in gray; all dimensions are in inches. Design numbers correspond to those on Effectiveness Curves, Fig. 3, and in Performance Table II. Unless indicated otherwise, mild-steel pole pieces will extend only slightly beyond the magnet material at the working face.







3 Effectiveness Curves for designing holding magnets. Circled numbers correspond to design numbers in Performance Table II and with the 24 basic designs.



treatment. Cast Alnico can be made in multiple bars which can be broken apart to form separate bar magnets.

APPLYING DESIGN DATA

The principal curves for holding-magnet design, Fig. 3, are plotted for each of the 24 basic designs in terms of pull effectiveness E vs reach-factor $G/\sqrt{P}$, where G is air gap and P is pull, Table I. Effectiveness measures weight of magnetic material for a given pull and air gap; reach-factor measures air-gap size for a given pull. Together, they define magnet performance.

A magnet with high pull effectiveness has high pull for low magnetic-material weight W. W is selected, rather than total assembly weight W_T including steel pole pieces, because it is usually the major cost item.

Pull effectiveness E $(= PG/W)$ remains constant between any two geometrically similar magnet systems because P is proportional to the ratio-factor K^2 (face area), G is proportional to factor K (length of magnet), and PG is proportional to volume and weight. This proportionality is significant because P and G required for a new design are known or specified, and a calculation of W can be made from the value of PG/W.

Reach factor $G/\sqrt{P}$ measures how large G is for a specified pull. P is proportional to area, therefore $\sqrt{P}$, like G, is proportional to the linear dimension. Result is a constant reach-factor value for all geometrically similar magnets. This makes it possible to use the same charts, effectiveness vs reach factor, for any magnets geometrically similar to the 24 basic designs, regardless of size.

Zero-gap effectiveness E_0 has a different numerical value than for a magnet with an air gap, because here G is zero. However, a magnet in direct contact with an armature will have high pull for low weight if its effectiveness value is high.

HOW TO USE THE METHOD

Design procedures for holding magnets with an air gap and those operating in intimate contact with the mild-steel armature are described on page 100. An example using each procedure:

• A holding magnet, air-gap type, is required to produce 10-lb pull at 0.05-in. gap. Non-oriented barium ferrite is specified as the magnet material. Reach factor $G/\sqrt{P}$ is $0.05/\sqrt{10} = 0.0158$. In the effectiveness curves, designs 2, 3, and 6 have about the same effectiveness at this reach factor. Design 2 is selected because Fig. 2 shows it is simplest in construction. Here, from the effectiveness curves, $E = 1.06$.

Weight of permanent-magnet material required is: $PG/1.06 = 10 \times 0.05/1.06 = 0.472$ lb. Design 2 in Performance Table II uses only 0.27 lb of magnetic material, so each linear dimension of Design 2 from Fig. 2 is multiplied by $K = \sqrt[3]{0.472/0.27} = 1.205$ to establish new magnet dimensions. Diameter becomes $1.205 \times 2.5 = 3.013$ in.; and thickness of steel back plate becomes $1.205 \times 0.06 = 0.072$ in.

• A magnet that has zero air gap and 100-lb pull is required; and it is decided to use oriented barium ferrite, Design 11. From the performance table, effectiveness $E_0 = P_0^{2/3}/W = 2400$. For 100-lb pull, weight of magnetic material is $100^{2/3}/2400 = 0.416$ lb. Linear dimensions from Fig. 2 are then multiplied by $K = \sqrt[3]{0.416/0.27} = 1.16$. For example, over-all length of new magnet becomes $1.16 \times 2.5 = 2.9$ in., and minimum armature thickness becomes $1.16 \times 0.16 = 0.186$ in.

ARMATURE DESIGN

For maximum pull in zero-gap applications, the mild-steel armature should be at least the same relative thickness as armatures in Table II to prevent saturation; armature face dimensions should be larger than those of the magnet by at least the length of the gap. Data presented here were obtained with armature plates meeting these requirements.

Pull and gap values in the tables and charts are for magnets or assemblies pulling against steel armature plates. If greater 'reach' is required, the steel armature can be replaced by a magnet. For example, two like magnets, pulling one against the other, produce a given pull at twice the gap.

FABRICATING MAGNET ASSEMBLIES

Cost may be lower with adhesives to join the parts. Epoxy adhesives are recommended for assemblies subject to high stress at the glue joint. Examples are Designs 5, 6, 12, 18, 20 and 21 in Fig. 2. Satisfactory epoxy cements are: Bond Master M-620, Rubber & Asbestos Corp.; Tylene Resin TR 10 with hardener TH26, Tylene Plastics Inc.; Versamid 125, General Mills Inc., with hardener Epon 828, Shell Chemical Corp.

Air-drying glues are suitable when high bond strength is not required, as in Designs 1, 2, 3, 4, 7, 8, 9, 10, 11 and 19. Such cements include Pliobond by Goodyear, and EC-1248 by Minnesota Mining & Manufacturing Co.

Table II—Performance of 24 Basic Holding-Magnet Designs, and Minimum Armature Thickness.

Design numbers correspond to numbers on Effectiveness Curves, Fig. 3, and with illustrations on Fig. 2.

Magnetic Material	Design Number	Magnets or Assemblies	Weight, lb			Pull For Air Gaps Shown, lb										Min Armature Thickness, For Max Pull, in.	Zero Gap Effectiveness, E_o
			Magnetic Material		Magnet Assembly	0.00	0.002	0.005	0.010	0.02	0.04	0.08	0.15	0.3	0.6		
			Actual	Practical Min													
Barium Ferrite, Non-oriented	1	Rectangular, magnetized on one face	0.27	0.01	0.33	8.5	—	—	—	6.2	4.8	3.5	2.1	0.8	—	0.10	92
	2	Ring, magnetized on one face	↓	↓	0.35	12	—	—	—	9.1	7.1	4.8	2.7	0.8	—	0.05	150
	3	Round			0.66	61	40	30	20	13.0	7.0	3	—	—	—	0.20	1800
	4	Rectangular, in channel pole piece			0.43	42	23	17.2	13.5	9.9	5.5	2.2	—	—	—	0.12	1000
	5	Single sandwich			0.55	77	46	39	25	12.0	6.0	2.0	—	—	—	0.13	2500
	6	Double sandwich			0.55	90	55	44	30	16.0	8.0	—	—	—	—	0.12	3200
Barium Ferrite, Oriented	7	Cup assembly	0.27	0.15	0.54	100	—	—	48	36	24	13.0	7.0	2.0	—	0.11	3700
	8	Ring, magnetized on one face	↓	↓	0.50	26	—	—	—	21.6	17.7	12.8	8.0	3.7	0.9	0.20	490
	9	Round			0.72	100	—	66	54	39	22	11.0	4.0	1.0	—	0.25	3700
	10	Rectangular, magnetized on one face			0.53	20	—	—	—	17.6	14.5	11.0	7.5	3.2	0.8	0.30	300
	11	Rectangular in channel pole piece			0.57	75	—	52	40	28	18.0	11.0	6.0	2.0	—	0.16	2400
	12	Sandwich			0.83	150	—	103	75	41	22	10.0	—	—	—	0.35	6800
Alnico V, Cast, Oriented	13	Rectangular bar	0.27	0.01	—	19	—	—	12.0	9.7	7.2	5.2	3.1	1.3	0.4	0.30	310
	14	Round bar		0.01	—	20	—	—	12.8	9.6	7.2	4.8	2.7	1.3	0.4	0.30	330
	15	Plain U		0.01	—	18	—	—	12.5	9.4	7.0	4.5	2.6	1.2	0.4	0.30	270
	16	Special shape U		0.27	—	35	—	—	22.5	14.2	9.2	5.0	2.5	0.8	—	0.20	770
	17	6-pole side-pole		0.05	—	33	—	23.5	18.5	12.9	7.6	3.9	1.1	—	—	0.15	700
	18	Bar with pole pieces		0.003	0.70	90	—	57	39	27	16.0	8.0	3.5	—	—	0.35	3200
	19	2-pole side-pole		0.05	0.39	36	—	24.6	20.0	16.0	10.8	6.4	3.1	1.0	—	0.30	800
	20	Cup		0.002	0.72	60	—	41	32	22	12.0	6.0	2.4	0.8	—	0.20	1700
	21	Cup with center pole piece	↓	0.01	1.0	185	148	94	50	26	10.0	4.0	—	—	—	0.20	9300
Alnico Sintered — Non-oriented — II — Oriented — V	22	Round U — II	0.01	0.005	—	1.20	0.80	0.58	0.45	0.30	0.17	0.08	—	—	—	0.05	130
	23	Square-back U — II	↓	0.001	—	0.96	0.70	0.53	0.39	0.27	0.15	0.04	—	—	—	0.05	94
	24	Square-back U — V	↓	0.001	—	1.70	1.25	1.00	0.78	0.52	0.28	0.11	—	—	—	0.06	220

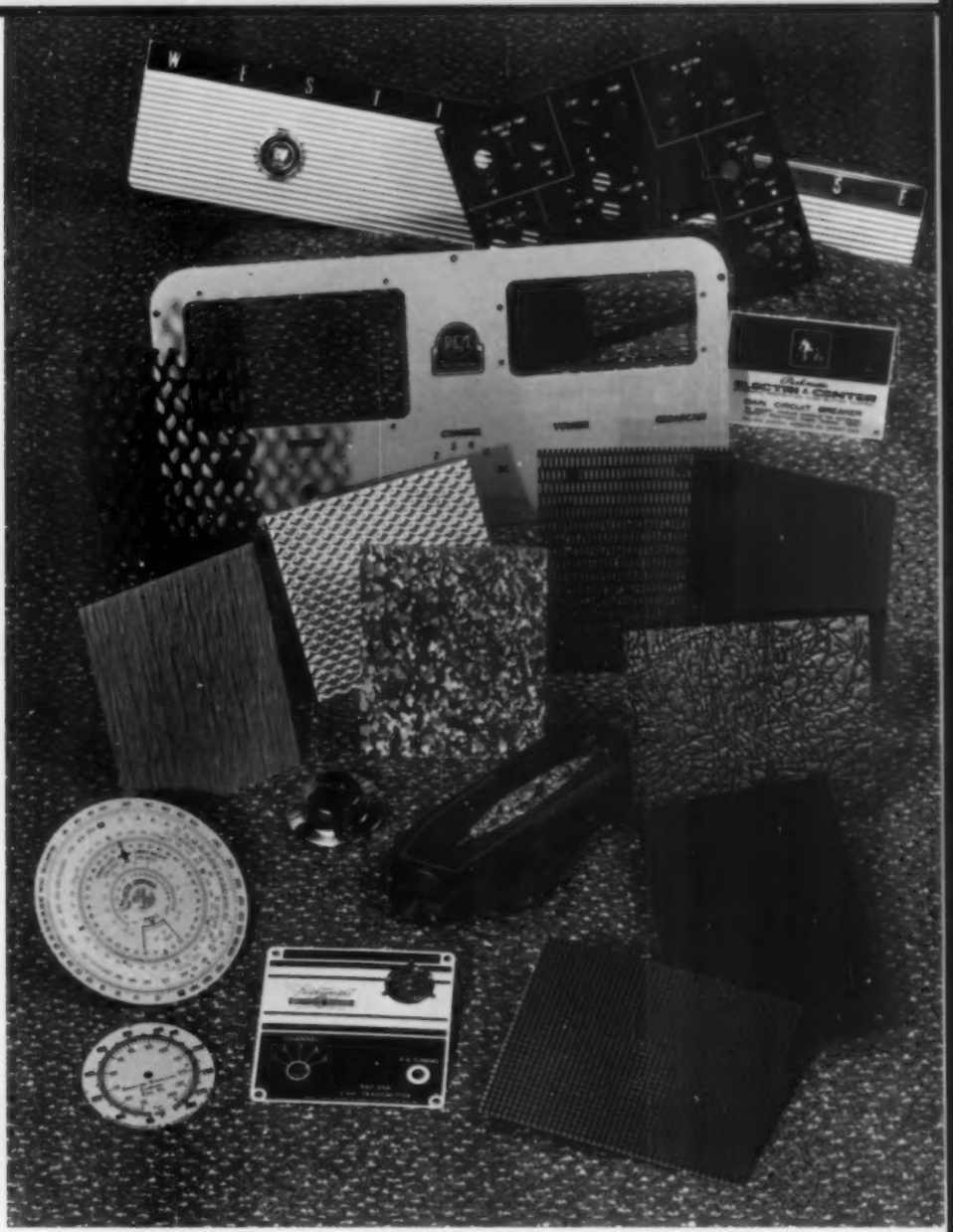
Design Procedure I—with Air Gap:

1. Specify pull P and gap G required.
2. Select magnetic material—page 95.
3. Using desired P and G, calculate reach-factor $G/\sqrt{P}$.
4. From effectiveness curves, Fig. 3, for the material selected, note which designs have the highest value E for previously calculated $G/\sqrt{P}$, and from the corresponding designs in Fig. 2, select the best one.
5. From effectiveness curve corresponding to this design, read off the value E at value of $G/\sqrt{P}$ obtained from step 3.
6. With this new value for E, calculate weight of the desired new magnet material, using values of P and G from step 2: $W_N = PG/E$.
7. Obtain linear dimensions of new magnet by multiplying each linear dimension of the basic magnet chosen from Fig. 2, by the factor $K = \sqrt[3]{W_N/W}$ where W is weight of magnetic material in basic holding-magnet design obtained from Table II.

Design Procedure II—with Zero Air Gap:

1. Specify zero-gap pull P_o required by application.
2. Select type of magnetic material to be used, from considerations described under "Selection of Materials."
3. From Table II, note which designs have the highest zero-gap effectiveness E_o for the material.
4. From Fig. 2, select best design. For this design, refer to Table II and read off value of E_o.
5. With this value of E_o, calculate weight of the magnetic material W_N in the new design using the value of pull P_o from step 1: $W_N = P_o^{3/2}/E_o$.
6. To obtain linear dimensions of new magnet, multiply each linear dimension of the basic magnet design chosen in step 4 by the factor $K = \sqrt[3]{W_N/W}$; W is weight of magnetic material in basic holding-magnet design obtained from Table II.

COLOR AND TEXTURES FOR ALUMINUM



R. V. VANDEN BERG
Alcoa Process Development Laboratories
Aluminum Co. of America
New Kensington, Penn.

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Exceptional range of surface treatments — mechanical, chemical, and electrochemical — plus some coloring methods peculiar to this metal provide wide scope for attractive product identification.

- Natural surface protected by transparent oxide is pleasing and permanent.
- Oxidized surface can be dyed with rich, strong colors — or delicate pastels.
- Excellent forming characteristics allow range of textures from lustrous to rough.
- Fast response to etchants offers a variety of three-dimensional effects.
- Corrosion resistance of bare metal, abrasion resistance of oxide surface add permanence and protection against wear.

HOW TEXTURE AND COLOR ARE ADDED TO ALUMINUM SURFACES

	Embossed or Coined	Acid Etched	Litho-graph	Anodic Color	Anodic Photo	Engraved
Type of Product	Surface texture or identification	Nameplates, dials, scales, identification plates	Nameplates, instruction plates	Nameplates, dials, scales identification, plates and surface decoration	Nameplates, scales, dials, diagrams	Diagrams and surface decoration
Cost	Low cost in high quantities	Moderate cost	Low cost	High cost	High cost	High cost
Color Possibilities	Colored anodic or enamel fill	Enamel fill or colored anodic	Printed any color	Unlimited organic dyestuffs or pigments	Backgrounds may be color, prints in sepia or black	Enamel filled or anodic any color
Resistance to Abrasion	Good if colored anodic	Poor. Color areas must be recessed	Poor	High	High	High if anodic color
Depth of detail		0.003 in.	On surface only	Coating 0.0001 to 0.0004 in. integral with surface thickness		0.020 in.
Resistance to fading		Excellent	Excellent	Good to excellent if proper dye or pigment used		
Complexity of operation	Requires press or rolls	Printing press or silk screen for resist. Tanks and acid etchants	Printing press	Dc electrical equipment and tank	Dc electrical equipment, tanks and photograph equipment	
Applied by	Rolls or presses	Acid etchants	Printing presses	Anodic oxidation		Pantograph or hand engraving
Special qualities	Sharp detail	Deep detail on larger quantities	Large quantities with economy	High resistance to abrasion with attractive colors	Exceptional detail and accuracy	Attractive designs possible

The role of aluminum as an eye-appeal metal can be viewed in depth. It offers good forming properties, ready response to etchants and dependable adherence for inks and enamels. These characteristics make the lightweight metal a good base for texture and color treatments giving attractive product identification of conventional type.

But in addition, aluminum can be given a hard, wear-resistant oxide surface. And this can be dyed to produce built-in, permanent color in an unlimited range of hues and tones, in single-color areas or multi-color effects, on flat or textured surfaces.

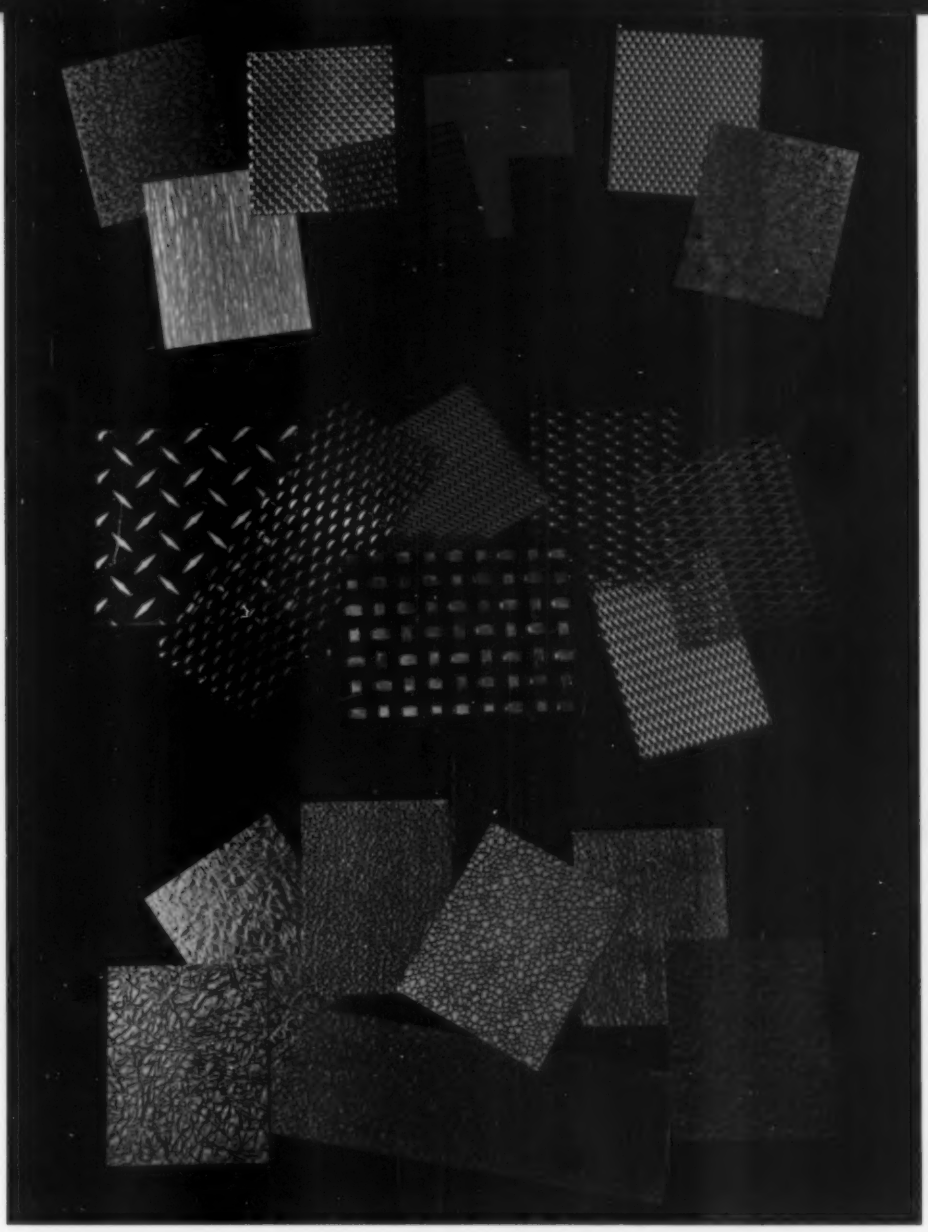
TEXTURE AND SURFACE DESIGN

Even without color, the design possibilities of aluminum are exploitable many ways.

Textures can be developed by mechanical finishing treatments such as buffing, polishing, brushing, blasting and burnishing, with surfaces ranging from smooth lustrous to rough matte. Bright reflective surfaces are created by chemical bright dips or electropolishing; matte textures, by acid or alkaline etching processes. Hammering, embossing and coining can produce both texture and surface design.

Perforated sheet offers a variety of decorative effects for panels and screens. Embossing sheet by press or roll can produce uniform or variegated surface designs, some closely resembling hammered or cast surfaces. Coining gives sharp detail. Pattern-rolled sheet is produced by embossing or coining. Engraving, by hand or machine, has advantages of deep detail and good accuracy, and while slow and costly, is particularly effective with colored anodic finishes.

Etching may employ either acid or alkaline solutions. A recently developed alkaline process with an electrolyte of barium hydroxide (see Patent Note at end of article) is less subject to undercutting. Resists are applied by printing, screening, stenciling, spraying



TEXTURE PLUS ANODIC COLOR

or photo-sensitizing. Photo-sensitive resists give accurate and fine detail.

The conventional fired-asphaltum resist is used in combination with lithographic ink applied by a master plate. Usual method is to dust fine, powdered asphaltum (200 mesh) over the moist, inked surface. After the surplus is removed, powder on the uninked areas is taken off by passing the work through talc. Remaining asphaltum then is fused to the ink at a temperature of 340-400F.

Acid etchants commonly used for deep etching aluminum at room temperature are:

- 20% hydrochloric acid
- 15% hydrochloride acid saturated with sodium chloride
- Ferric chloride 85 grams, hydrochloride acid 24 grams, water to make one liter.

Depth of etch for the first two acid solutions, commonly used for nameplates, is 0.005 to 0.007 in. Sodium chlorate, saccharic acid or nickel chloride are sometimes added to the ferric chloride etchant. This etchant produces a rough surface; for a more uniform finished surface, the natural oxide film is first removed from the aluminum surface by a pre-etch in dilute caustic soda solution or hydrofluoric acid. This is important primarily for large surfaces that are not to be enamel filled. Asphaltum is not affected by hydrofluoric acid solutions; hot caustic solutions will attack it, but cool dilute solutions can be used with short immersion time.

Metallurgical Finishes

Decorative effects are possible using the metallurgical characteristics of aluminum alloys. A new type, shown above and on the next page, is "spangled sheet." Abnormally large grains are induced, and an acid etch causes each grain to stand out in relief. Anodic color can be added by usual methods.

SURFACE TREATMENT PLUS COLOR

APPLICATION OF COLOR

For better identification or decorative effects, color can be added to recessed areas by filling with ink or synthetic enamel. Recessing is done by casting, embossing, coining, engraving or etching; the "fill" is generally applied by spraying and wiping.

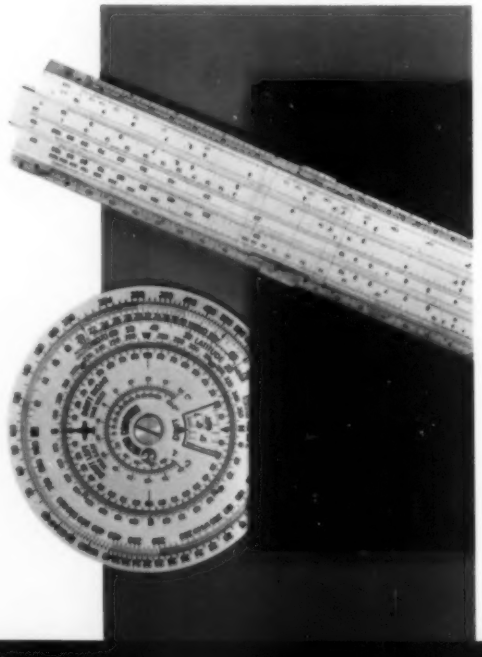
Lithography produces decorative surfaces excellent in detail, with almost unlimited color possibilities. It also is often the most economical. Different colors can be printed adjacent or superimposed, and printed sheet can be formed, as in bottle enclosures. While their abrasion resistance is low, printed surfaces are suitable for a variety of indoor applications, and the process is adaptable to both low or high production.

Silk screen process, though generally associated with signs and displays, will produce designs or text on a variety of surfaces, and is a practical method for producing moderate quantities at low cost. Color can be applied by ink, enamel or porcelain enamel. Silk screen process can also apply stop-offs, resists or masks as an intermediate step in etching, electroplating and anodizing.

Spraying with masks or stencils applies color for identification or decorative design in appliance and automotive trim, a method often used on colored Alumilite surfaces.

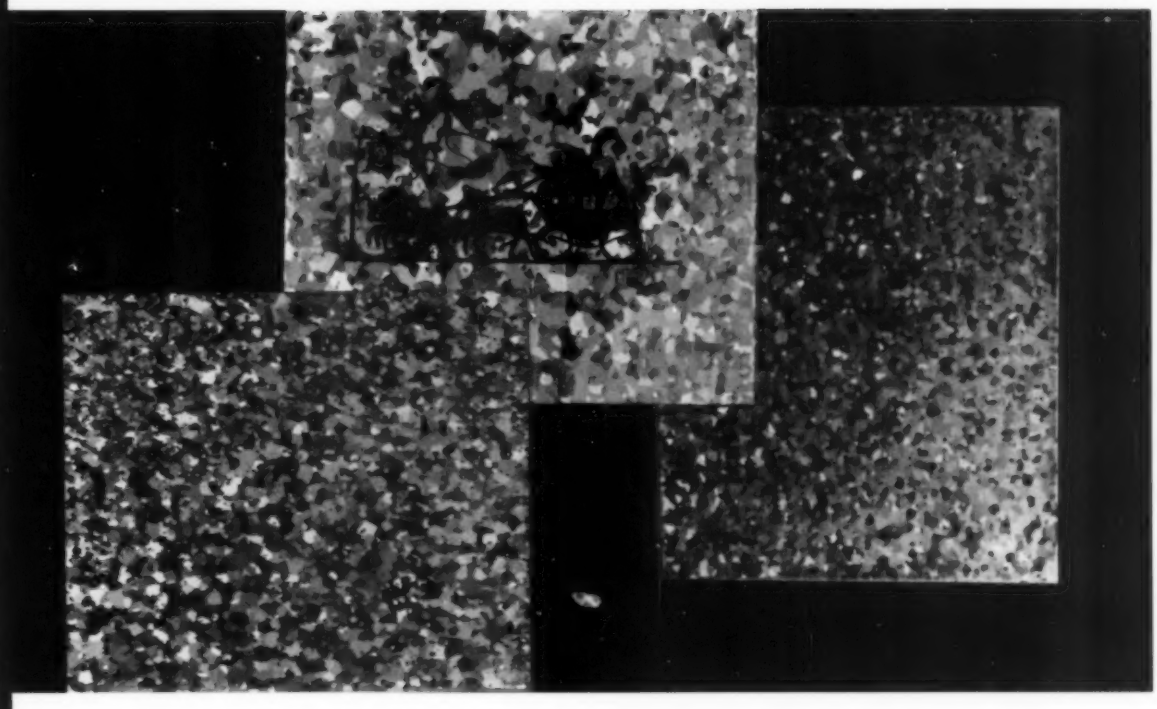
Alumilite finishes are produced by the electrochemical process of anodic oxidation. It converts the aluminum surface into a thick, adherent aluminum oxide integral with the metal. Two earlier articles (see Background Reading on last page) discuss this finish in detail. The finish will not chip or peel, is hard and abrasion resistant. Dilute sulfuric acid electrolytes produce transparent coatings that impart a distinctive metallic sheen to plain and colored surfaces; dilute chromic acid gives opaque coatings that are thinner and more flexible. Both types are porous as formed and can be colored with organic dyes. After it absorbs the dye, the porous surface can be sealed by dipping in a boiling nickel acetate solution.

PHOTOGRAPHIC PRECISION



SPANGLE SHEET

In preparation for this new surface texture, aluminum sheet is heat treated to obtain a large and uniform grain size. Deep etching produces reflecting surfaces oriented to the crystal axis of the grains.



Anodizing reproduces the surface from which it is formed. A matte surface produced by sand blasting offers contrast with a buffed surface: Embedded abrasive remains in the anodic coating and imparts a gray tone resembling the effect given by anodizing an aluminum alloy containing silicon. Chromium alloy content imparts a yellow tone, and manganese a brownish color to an anodic film.

Anodic coatings can be developed by batch, bulk, and continuous batch or strip processes. Coiled sheet and wire can be prefinished. While coatings formed in dilute sulfuric acid electrolyte have greater flexibility, the amount of forming is limited. Actual trials are often necessary to determine if the material will withstand the forming desired.

Photographic Process

For designs or identification requiring close dimensional tolerances, the photographic process (see Patent Note) offers a precise method of applying resists. The surface is prepared by buffing, etching or cleaning, and then a relatively thick anodic coating is formed. This coating is saturated by immersion in solutions of ammonium chloride, bromide or iodide. Then, the parts are immersed in a water solution of a silver compound, such as silver nitrate. It precipitates the silver halide in the pores of the anodic coating.

The process, much like sensitizing a photographic film, must be conducted under a "safe" light. After rinsing and drying, the photo-sensitive surface is ready for exposure and development.

This process produces a natural aluminum finish in combination with brown or black, depending on the "toning" techniques employed. The unsealed anodic coating not covered by the design can be colored and sealed in nickel-acetate solution. Result is a brown or black design against a colored background.

Electroplating

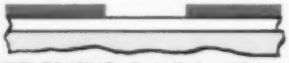
Electroplating also gives a finishing system for aluminum where identification or decoration is desired. A zinc immersion process removes the natural oxide film from the aluminum surface, and replaces it with zinc. After a copper strike is applied over the zinc layer, plating procedures are the same as for brass, nickel, chromium, silver, gold or other metals. Gold plating over a coined aluminum surface offers an attractive contrast with the aluminum surfaces.

CHART ONE

1. . PREPARE SURFACE by buffing, etching or cleaning.

2. . ANODIZE.

3. . RINSE, air-dry or force air-dry.



4. . HEAVY COATING of air-drying lithographic ink or sprayed asphaltum solution.

5. . ADD ORGANIC DYE or mineral pigment.

6. . RINSE, seal with nickel acetate, rinse, dry, and remove resist.

7. . SEAL colored coating in boiling water, rinse and dry.

CHART TWO

1. . PREPARE SURFACE by buffing, etching or cleaning.

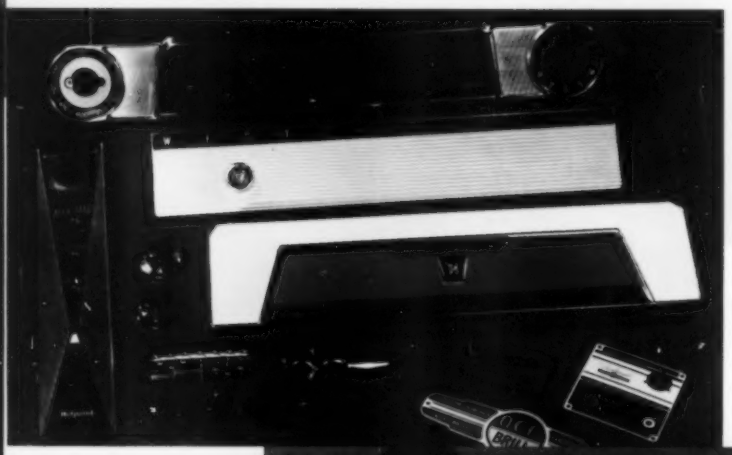
2. . ANODIZE.

3. . RINSE and dry.

4. . APPLY INK by printing.

5. . DRY, and color by immersion in water-soluble dye.

6. . RINSE and seal in boiling water; remove excess ink by solvent.



MULTICOLOR METHODS *for anodized surfaces*

PRINTED AND ENAMEL INLAY

ANODIC COLOR

CHART THREE

1. . PREPARE SURFACE by buffing, etching or cleaning.

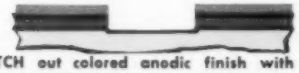
2. . ANODIZE.

3. . RINSE.

4. . COLOR WITH ORGANIC DYE or pigment (omit for uncolored coating).

5. . RINSE, seal in boiling nickel acetate, rinse and dry in air or oven at 200 F.

6. . APPLY LITHOGRAPHIC INK and, while still moist, dust with 200-mesh powdered asphaltum. Remove surplus and fuse to ink in oven at 340-400 F.



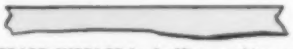
7. . ETCH out colored anodic finish with hydrofluoric acid solution.

8. . RINSE, and anodize.

9. . RINSE, and color with organic dye or pigment.

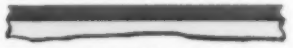
10. . RINSE, seal in nickel acetate solution, and remove mask with organic solvent.

CHART FOUR



1. . PREPARE SURFACE by buffing, etching or cleaning.

2. . ANODIZE.



3. . RINSE, and color with organic dye.

4. . RINSE, and air-dry or force air-dry at 200 F.

5. . APPLY SPECIAL INK (not absorbed by unsealed anodic coating).

6. . BLEACH (see solutions listed in text).

7. . RINSE, and color (same as step 3).

8. . RINSE, seal in boiling nickel acetate, dry and remove resist.

9. . SEAL, (same as step 8) rinse and dry.

ANODIC COLOR METHODS

When combined with engraving or highlighting, the anodic coating is removed, without chipping or peeling, by mechanically abrading or cutting selected areas. When applied to patterned or expanded sheet, color on high points can be removed by polishing. The aluminum surface is first buffed, etched or cleaned; then anodized and colored with either organic dyes or mineral pigments. After sealing, rinsing and drying, the anodized surface is engraved or removed by mechanically cutting through the oxide coating, exposing the natural color of the aluminum. Portions of the engraved surface may be enamel filled, or again anodized and colored by a patented process (see Patent Note). When sealed, the initial anodic coating acts as resist for the second anodic treatment.

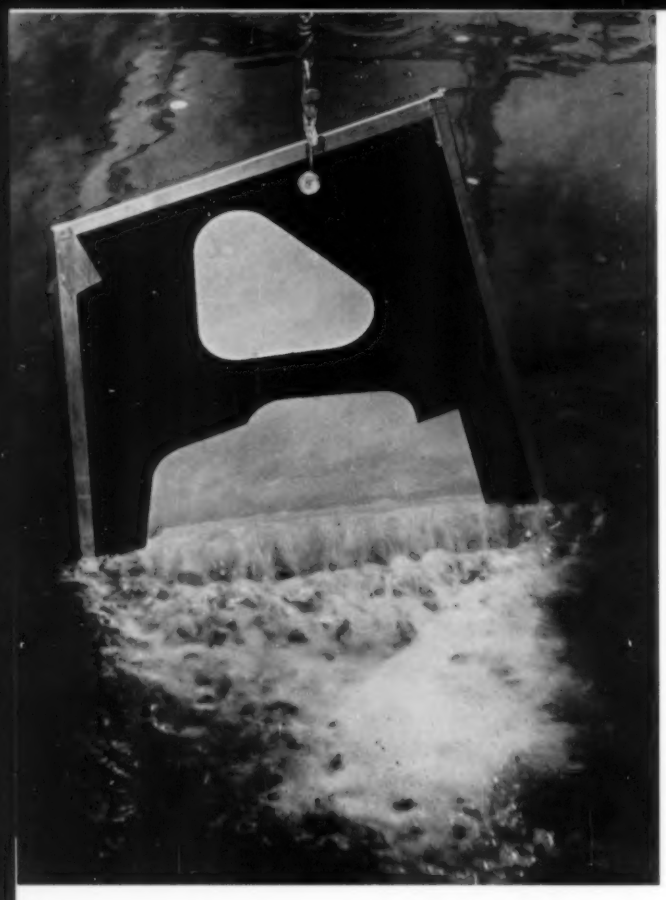
When etching is used to produce design or identification, recessed areas usually are filled with enamel. Etched areas in colored anodic material can be left as etched or the recess filled with enamel. A deep recess gives good protection from wear.

Two-color effects on the anodic surface can be obtained by the direct stop-off method detailed in Chart 1. The ink becomes a resist for the color. After sealing, the resist is removed and the masked areas are then sealed. To remove plain or colored anodic coatings in selected areas without attacking the aluminum, use a hot (212 F) etch consisting of 30 grams CrO_3 and 50 cc H_3PO_4 in a liter of water. Caution: Asphaltum resists do not stand up under oxidizing power of the solution at this operating temperature.

Color can be selectively applied directly to an unsealed anodized surface by the Sin Valuminum Process (see Patent Note). As shown in Chart 2, after the aluminum surface is prepared and anodized, a special ink goes on by silk screen, printing or spraying. It serves both as a dye for the anodic layer under it and a resist. After the ink dries, a second color is applied to the remaining surface by the conventional method of immersing in a water solution of organic dye or pigment. After sealing, the surface is rinsed, dried and the excess ink removed by a suitable solvent. The result is a two-color identification or design in a flush surface. These color effects can be applied to curved or contoured surfaces.

Another two-color technique applies a resist to a colored anodic finish; then, after the recess is etched and anodized, it is colored or left plain. The process is diagrammed in Chart 3. If enamel fill is desired instead of colored anodic, the recess is further etched with hydrochloric acid to the depth needed for a protected enamel inlay.

A multicolor method based on a bleach process, shown in Chart 4, uses inks with a glycerophtalic vehicle as a resist. These inks do not penetrate the



CHEMICAL MILLING . . .
is a special form of selective deep etching (Patent Note), in which large amounts of surface metal are removed to depths as much as 1 in. Generally, alkaline etchants are used at high temperatures to remove surface metal at approximately 0.001 in. per min. Dimensional tolerances of 0.002 are possible. But because etchants usually are alkaline solutions, asphaltum resists must be replaced by other masking materials.

This is a typical aircraft part being lowered into the caustic bath, at North American Aviation. Mask is a black paint.

anodized surface. First step is to color the anodic coating but leave it unsealed. The ink resist is applied and the unprotected surface bleached by one of these oxidizing solutions used at room temperature:

- 20% nitric acid.
- 50 grams sulphuric acid, 200 cc chromic acid in a liter of water.
- 50 grams nitric acid, 500 cc chromic acid in a liter of water.

Next, the bleached anodic coating is colored. Additional combinations of color and design can be applied before the coating is sealed, but the number of colors is limited. After four or five bleaching cycles the anodic coating loses its ability to absorb dyes.

Mottled effects (see Patent Note) are produced on anodized surfaces by a technique similar to the bleach method. Color is removed from the unsealed colored coating with nitric acid, by a method that produces the variegated color effects. Combinations of color can also be used, and dyes produce marbleized effects by spraying or stippling with a sponge or cloth. The water dye solution is thickened with gum tragacanth.

PATENTS. Some of these finishes and coloring processes are covered by patents containing further data on methods of application.

Alkaline anodic etching process employing barium hydroxide electrolyte, US Patent 2,472,304; Aluminum Co. of America.

Photographic process, US Patent 2,115,339; Aluminum Co. of America.

Two-color anodizing process employing engraving, US Patent 2,691,627; Scovill Mfg. Co.

Sin Valuminum process, US Patent 2,614,912; Sinclair & Valentine Co.

Mottled effects, US Patent 2,127,885; Aluminum Co. of America.

Chemical Milling, US Patent 2,739,-047 and others; North American Aviation and Turco Products, Inc.

BACKGROUND READING. Earlier articles on finishing of aluminum surfaces:

"Prefinished Aluminum," April '56, p 135; electrochemical, painted and electroplated coatings on sheet; forming limitations of each process, and new types of mill products available.

"Nickel and Chromium Electroplates for Aluminum," Mid-Oct '54, p C 2; summary of tests at Navy Bureau of Aeronautics on strength and fatigue of base metal, and wear and corrosion resistance of surface.

"Mechanical Properties of Aluminum Hard Coatings," Sept '54, p 136; effect of heavy oxide films on fatigue, tensile and compressive strength, and corrosion and wear resistance.

"Finishes for Aluminum Products," Oct '51, p 179; early article giving detailed alloy specifications, surface pretreatment and methods of application for mechanical, chemical, electrochemical and organic finishes.

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DESIGN DIGEST ISSUE

(published about October 15)

including more than 100 articles in 10 sections . . .

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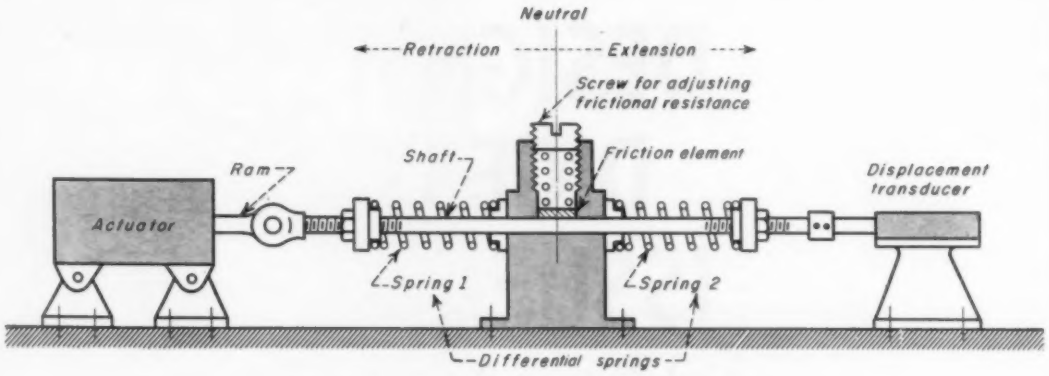


Differential-spring system for simulating push-pull loads on an actuator. The system is shown with ram and shaft in the neutral position.

DIFFERENTIAL SPRINGS can simulate load

Analysis of forces and effect of frictional resistance in differential spring systems using two pre-loaded springs operating back-to-back.

GEORGE H. LOGAN
North American Aviation
Los Angeles, Calif.

Many design problems involve an actuating device to drive a mechanical load with a force that is linearly proportional to displacement from neutral. To test the device it may be inconvenient to attach the actual load system, or "parent-system" to the actuator. If the desired force-displacement relationship is known, the load can be readily simulated with the differential-spring system shown in Fig. 1 in which two springs are arranged to operate back-to-back.

The friction element is a means for simulating the known friction load in the parent-system. Friction drag on the shaft can be adjusted to a desired value by increasing or decreasing the compression of the vertical spring that bears against the friction pad. Both static (breakaway) and dynamic (running) frictional forces can be directly measured by axial pull on the shaft with a spring balance. In measuring the frictional force both springs are omitted from the system and then installed when the final position of the adjusting screw is secured.

Usually both springs are made to the same specification and pre-loaded at assembly an amount t at neutral. Dimension t should be slightly greater than the maximum extension that either spring will experience when the shaft moves either way from its neutral position. Reason for pre-loading is so that the spring can be supported as shown with only the inactive end coils nested, and with no rubbing of the active coils against the shaft possible. Also, the spring rate f/x is most linear when spring excursion occurs in either direction from an initial compression.

If a record of displacement against time is desired, a potentiometer-type displacement transducer can be coupled to the end of the shaft. The output voltage of the transducer, an analog of the shaft and ram displacement, is made the input to an oscillograph.

Analysis of Forces

Neglecting friction for the time being, when the ram is retracted an amount x the forces in the system are

$$F = f_1 - f_2$$
$$f_1 = kt + kx$$
$$f_2 = kt - kx$$

Therefore $F = 2kx$

But $F = k'x$

Therefore $k' = 2k$ (1)

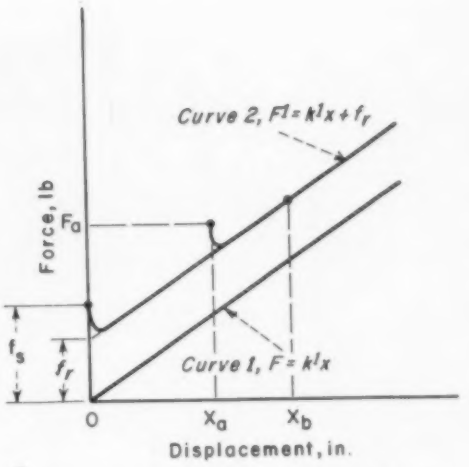
Thus, when two identical, pre-loaded springs are used each spring must be designed to exhibit a spring rate that is one-half the desired spring rate of the simulating system.

For the more general case where both the spring rates and pre-loading are not identical, the forces are

$$F = f_1 - f_2$$
$$= k_1 t_1 + k_1 x - k_2 t_2 + k_2 x$$

SYMBOLS

- k — spring rate of Spring #1 or Spring #2, lb/in.
- k' — spring rate of simulating system, lb/in.
- f — load on Spring #1 or Spring #2, lb
- f_s — static friction force
- f_r — moving friction force
- F — force on simulating system without friction, lb
- F' — force on parent system with friction, lb
- d — spring wire diameter, in.
- D — mean diameter of coils, in.
- G — torsional modulus of elasticity, lb/in.^{2}
- K — Wahl's constant for helical springs
- S — torsional stress, lb/in.^{2}
- t — amount of pre-load on a spring, in.
- N — number of active coils
- x — displacement of shaft from neutral, in.



2 Force displacement curves of a differential-spring system with and without frictional resistance.

but $k_1t_1 = k_2t_2$ for equilibrium at neutral, therefore

$$F = k_1x + k_2x = k'x$$

$$k' = k_1 + k_2 \qquad (2)$$

Thus, when two identical springs are used and both are pre-loaded a distance t, and both retain some compression for any value of x, then the individual springs are each designed to exhibit a spring rate that is one-half the desired simulating-system spring rate.

Eq (2) can be used in subsequent calculations if it is found that fabrication of the springs is not sufficiently precise to consider them identical.

Effect of Frictional Resistance

Unless quite rough approximations are adequate, the effect of static and running friction must be introduced into the analysis. The effect of friction on force-displacement characteristics is shown in Fig. 2. Curve 1 shows the $F = k'x$ characteristic for a frictionless system containing a pair of identical pre-loaded springs; curve 2 describes the characteristic of the parent-system with friction, $F' = k'x + f_r$.

For the simulating-system to have the same characteristics of the parent-system, the springs are designed to produce Curve 1 parallel with Curve 2. The friction element is then adjusted to effect a static frictional force of f_s and a running frictional force of f_r, thus shifting Curve 1 vertically upward an amount equal to f_r.

Adjustment of the friction element may require some trial-and-error manipulations. In general, the larger the coefficient of friction between the friction pad and shaft, the greater will be the difference between f_s and f_r. Actually, very few set-ups of this nature require ultra-precision and the variation of f_r with translational speed is ignored.

The frictional force f_s will change to f_r almost at the moment that breakaway occurs and movement begins. Thus a decreasing force will accompany the first incremental displacement from neutral. Similarly, if the spring system is held stationary at any departure from neutral such as x_a, actuating force must first attain the magniture F_a before the shaft will start moving to x_b.

For a helical spring, the number of active coils are

$$N = Gd^4/8kD^3 \qquad (3)$$

But $k = k'/2$, therefore

$$N = Gd^4/4k'D^3 \qquad (4)$$

$$S = 8fD/\pi d^3 \qquad (5)$$

where

$$f = k(t + x_{max})$$

For best performance, the ends of the springs should be closed and ground square. Such springs have one inactive coil at each end; hence the total coils equals $N + 2$.

The remaining details of spring design are straightforward. With a few minor exceptions, the above analyses would hold true if two extension springs are used in place of two compression springs.

EDITOR'S NOTE: Latest research on *surge waves in compression springs* indicates that there is "velocity barrier" that a mass propelled by a precompressed spring cannot exceed no matter what the size of the spring. This velocity barrier also limits the expansion rate of springs. In addition, photographs show that a spring receiving a shock does not vibrate harmonically as popularly assumed. These and other facts on dynamic behavior of springs were presented with newly developed design equations in "Surge Waves in Compression Springs," Aug '57, p 167.

Time required by springs to operate hydraulic valves has been discussed in "Calculating Time Lag of Hydraulic and Pneumatic Valves," June '56, p 158.

TECHNICAL NEWS

Fig. 1—Carbide tools in rapid sequence cut off tubing for cups in this battery of single-spindle automatics. Speeds are four times as high (475 sfpm) and feeds twice as high as they were, so each machine produces eight times what the older ones did. New cutoff tools save a mile of tubing a month (1,000,000 cups). Tubing is hot-rolled to save 2 to $4 per tube over cold-finishing. Variations of up to 0.060 in. OD are handled by a new design chuck incorporating Belleville springs, which have nearly flat load deflection curves, so tubes can be loaded and machines operated automatically. Stock racks are of special design, handle an 8-hour supply of tube automatically. The operator only removes the tube butt and restarts the machine.

Standardize—And Save

BECAUSE CUSTOMERS WERE FIRST SOLD on savings possible by standardizing bearing applications to sizes adapted to high production, The Timken Roller Bearing Company could build its Bucyrus, Ohio, plant and develop the "Bucyrus Concept" (PE—Sept. 23, p. 29). Eleven production lines, all heavily mechanized, turn out 34 cup sizes. Only 14 cups and cones are 80% of the volume. If they could be made 100%, perhaps 10% further cost savings would be possible, even though present costs are 15% under those in 1953 when the bearings were made by conventional methods.

Some 33 million cups and 27 million cones can be produced annually in this $12¼-million plant, kept a well-guarded secret for three years or longer. It turns out 192 bearings per man per shift, as compared with 30 for the all-automatic Soviet plant announced earlier.

One secret of the plant is special or adapted machine tools for the short strokes, speeds, automatic feeds and ejection required (only manual operations are final inspection and cone wrapping). To overcome builders' objections to the added engineering costs for these machines, Timken paid the costs or did its own designing and building in some cases. Mockups of special machines were tested and analyzed in a mocked-up line before actual units were built, so installation problems were minimized. All units are designed for quick replacement in case of failure despite an elaborate preventive-maintenance program. Because tolerances are relatively loose on the automotive, farm-machinery and similar bearings produced, the typical bearing sells for 1/40th the cost of the close-tolerance missile and instrument bearings made at the company's New Philadelphia, Ohio, plant.

Elaborate banking setups smooth out flow, permit quality-control checking, and allow the machines to operate on a 3-shift, 5-day week, while the endothermic heat-treat operates on a more-economic continuous basis. Elaborate interlocks with photocells assure steady flow to all machines. Tooling a line for a new cup costs $20,000, so the economical run is two weeks or longer (150,000 to 500,000 pc).

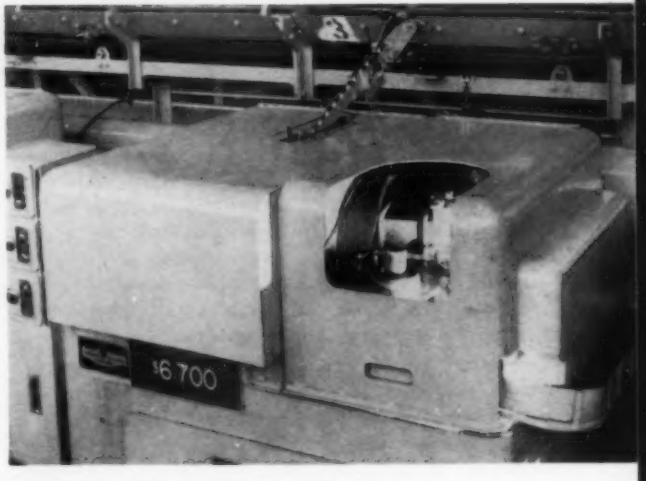


Fig. 2—Tape honing replaces the usual stones on the tapered ID of the cup, and produces an 8 mu/in. finish in 8 to 12 sec, depending on size. Tape is fed from and to a reel over a rapidly reciprocating head as the cup rotates. Note auto feed (top center) and ejection (right). A plate on each machine impresses the operator with its cost.

Timken designed a special hydraulic system for automatics that raised productivity 30%. Four slides operate off the camshaft, but just before cutoff a separate hydraulic system retracts the end-working tool slide, then re-engages it to the cam at the next cycle. Another new design is a pickoff finger which catches the rough-machined piece at cutoff to keep it from chips; the finger actuates a shutoff if no part is delivered.

New heat-treating equipment and methods are used.

A spiral-retort carburizing furnace has a slightly positive-pressure atmosphere of endothermic and natural gases. Carburizing temperature is 1700 F, cycle 5½ to 8 hr to produce a case 0.025 to 0.040 in. deep, as required. Surface is 1% C min, progressing to about 0.20% C at the core. Parts then go into a sealed oil quench, are picked up by a spiral conveyor, taken through a washer, and fed into a reheat furnace at 1510F. Smaller parts that do not distort excessively go through a small spiral retort, larger ones through a continuous-pusher furnace with automatic-plug quench. After washing, parts are tempered at 360F.

Employees, carefully selected for mechanical aptitude, average 29 years old, are high-school graduates. Income averages $3.50 per hour with bonus (averaging 25%), which all hourly paid people share. An innovation that prevents boredom is the rotation of operators (except heat-treat) and foremen from area to area. There are about 600 employees, some 60% from Bucyrus.

Timken is now building a similar single line for railroad freight-car bearings at Columbus. It will begin operation Jan. 1, 1958. Cost will be $7.5-million—about five times the Bucyrus line cost—because of the much larger bore size (5 to 6.5 in.). Tests indicate roller bearings can cut freight-hauling costs 22%, and only 50,000 of the nation's 2,000,000 cars have been so equipped, so Bucyrus feels that this is the biggest single current market for such bearings.

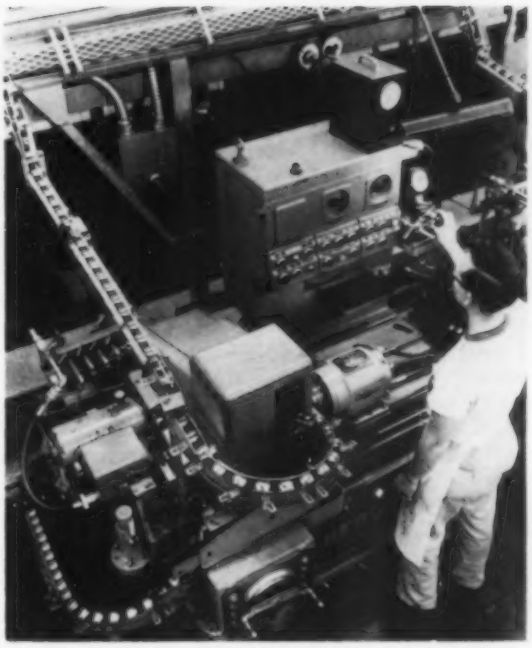


Fig. 3—Cone ID is ground to 0.0005 to 0.0008 in. tolerance in 14 to 25 sec, with gages on the machine permitting a quick check of tolerance and finish. Upper slide brings cones in, lower takes them back to another conveyor.

RRs Get Answer to Boxcar-Weight Puzzle

HAMMOND, IND.—One of railroading's most tantalizing problems—how to weigh a freight-laden boxcar accurately while it's coupled to the rest of the train—at last has an answer. It promises to save the nation's rail lines close to $200 million annually.

According to Samuel H. Levinson, president of International Railroads' Weighing Corp., simple engineering principles provided the solution. It's called the Marden Method after its inventor, Edward R. Marden, vice-president of the company.

Heart of the system is a short stretch of track with a half dozen different but extremely slight variations in grade. They give a series of humps, none higher than 1½ in., that enable scales to give an accurate reading. It's all done while the train is in motion.

The problem has been this: If the loaded car is coupled to the rest of the train during weighing, part of the car weight is transferred to coupling bars of two other cars—the one in front and one in back. Result: faulty weight, usually on the light side.

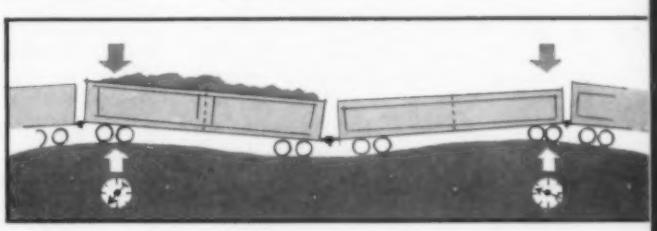
The alternative method—the one that has been favored—is to uncouple, sort, hump, weigh and recouple each car: a tedious, time-consuming, expensive practice that costs our railroads some $240 million a year.

Various other schemes have been tried through the years. Most notable has been the stomach-punching approach. It rammed cars 1 and 3 up off the track for an inch or two while car 2 was being weighed. But it damaged cars and proved uncontrollable. So, with other unworkable plans, it was scrapped.

Railroad executives will soon see the Marden System demonstrated in the Monon Railroad yards here. Grades are so built that front wheels of the car being weighed clear one hump and contact the scales. At this moment the coupling bars to car in front and rear ride clear.

Weight for front of the car is then registered, free from pressure of the other two cars. Next, the rear wheels roll down-grade and contact the scales. Again, the car is free of vertical tensions, and weight of the rear half registers—accurately.

The company has devised its own electronic scales that withstand vibrations resulting from 10-mph speeds, and weigh accurately. Handling coupled cars traveling at this speed, the system is expected to reduce weighing cost per car from $10 to less than $2.



New Look in Defense Contracts Shapes Up

WASHINGTON, D. C.–Pentagon brass are stumping the country laying an austerity program on the line to military contractors. And it all adds up to fewer government contracts with stricter controls on their costs.

Remarks by Air Force Chief of Material, Lt. Gen. C. S. Irvine now making the circuit of West Coast defense plants is typical of the new look that's emerging for all the services. Air Force production, he says, is being pared to the bone with only most promising projects to stay under production.

And, "If expenditures run over estimates," he cautions, "we will reduce quantity or–if price per unit goes too high–we may cancel the project. The day of over-runs is past. Poor planning, poor estimating–all connote poor management–so some old familiar faces may be missing."

Although it is not laid out in a special statement, some trends show:

Research and development contractors may find it harder to get production contracts. The policy has been to award initial production orders to the company doing R & D work. But, the Defense Department is not held to this, and it is likely to lean more to the lowest responsible bidder for production contracts.

EMPHASIS ON SYSTEM

More emphasis will be placed on the weapons system concept. Under this procedure a prime contractor is charged with full responsibility for delivering equipment ready for operation. In the past, this responsibility was spread to subcontractors with the procuring service responsible for coordinating the project.

Progress payments on new procurement are being reduced. Contractors may now collect 70% of total costs incurred instead of the previous 75%. Or they may collect 85% of the cost incurred for "direct" labor and materials–exclusive of overhead–instead of the former 90%. Small business can still collect up to 75% of total costs or 90% of direct labor and materials. Existing contracts with optional provisions on progress payments are subject to the new provisions, and others may be amended to align them.

Overtime payments, already cut back to really essential work, will be watched closely. And the military is doing some re-evaluation on what is to be classified as essential.

Letter contracts will be reduced. Their use has always been a stop gap measure to get work started until firm contracts are worked out. Now a project must be really urgent to get a go-ahead without a firm contract.

The shift away from cost-plus-fixed-fee contracts to cost-plus-incentive contracts will be stepped up, particularly for aircraft. It is a measure designed to save money by making it profitable for companies to hold down production costs.

OPPOSITION ARISES

Pentagon statements have been stirring up opposition from both major contractors and subcontractors who are begining to feel the pinch.

Washington, this week, is hearing especially pointed complaints from large defense contractors who claim government work is bleeding them. They feel they have not been getting a fair profit on the work they have been doing, and they want relief for the perilous period of budget cuts ahead. A survey made some months ago indicated that one out of every three government contractors was looking for a way to cut back government work.

Grievances are pinpointed on several characteristics of procurement policy. The renegotiation law, a holdover from World War II, is said by the big contractors to be unduly repressive. Under its procedures a contractor is not certain for two or three years whether or not he will make a profit on a contract. In the meantime, he must hold back apparent profits on the chance renegotiation will find the government calling in part of the money it has paid out. This, the big contractors claim, ties up badly needed capital.

They say, too, they are finding themselves short of operating money because of restrictions on so-called installment buying procedures and on progress payments.

The web of uncertainties surrounding almost any government contract is another source of dismay. The company, for example, that takes on a research and development contract may be hard hit if it does not get the production contract. Many big manufacturers claim that profits on R & D work are slender. They hope to make up for it when the item goes into production, but under the practice of passing along company know-how to other producers, they are often underbid on their own development work.

Design changes made while a product is being shaped up cut into company profits, too. Some companies claim they have had as many as half a dozen design changes on a single product. Then when production time comes it may be cancelled or curtailed.

Even when a company gets a production contract, there remains the threat that Congress will cut the budget and squeeze them out. A cancelled contract leaves its victim in a bind, say the companies. Payment is made for goods delivered, but many intangible items are not covered. Cancellation of a major project leaves a company with extra floor space and personnel that is an expense.

Some companies complain that government work is putting them behind in the race for commercial products. The exacting requirements for government work often mean that the best talent has to be shunted to it, putting the company at a disadvantage in the commercial development field. Further, plant space must be diverted.

PENTAGON REBUTS

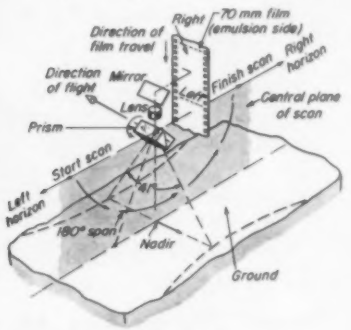
Some observers who claim the Pentagon is doing the best it can in a highly complex situation suggest that industry has not made out too badly. Contractors must like defense work or they wouldn't be in it. Many companies in existence today would probably not be around if it were not for government contracts. And a lot of government money has gone into plants and machinery for contractor use. As for impact on commercial lines, government work may have slowed down some companies, but in many cases it has hurtled them ahead on products.

Shutterless Aerial Camera Scans Horizon

NORWALK, CONN.—A lightweight, panoramic camera that operates without a shutter, and shows detail eight times better than the human eye can do, has been developed by the Perkin-Elmer Corp.

Designed for both military (open sky inspection, for example) and non-military aerial missions (geological surveys, course monitoring for navigational training, aircraft velocity studies, highway engineering), the new camera uses rapid-scanning principles to take successive pictures covering 180° from horizon to horizon across a plane's line of flight, with true velocity compensation throughout the scan.

Weighing less than 53 lb when fully loaded, measuring 18 in high and 3 ft long, and slightly thicker than the width of its 70mm film, the unit has a built-in image motion compensator, intervalometer, an automatic exposure control, and a wide range of scan rates and intervals.



Camera without shutter . . .

rode a Navy jet fighter at 400 mph and 7,000 ft altitude to shoot this continuous record of areas neighboring New York City. Top to bottom: Atlantic Ocean off Jones Beach; mid-Long Island shopping center; airfield; portions of the north shore; Connecticut, Westchester County and Hudson River. Naval Air Development Center photos were taken with a Perkin-Elmer Model 501 tracking camera.

No shutter is needed because exposures are made while the film moves across a slit in the camera. As the prism rotates, (see diagram), the image is "wiped" on the sensitized film. Scanning time is adjustable and can be set as fast as ¼ sec. Scanning across, rather than along the plane's flight path, gives a continuous record of the scene.

Operating on 28-d-c, the unit can be started and stopped by remote control, and set for either adjacent or stereo-overlapping pictures. In operation, images are focused on the film by a lens-mirror arrangement, and the film moves in synchronism with the image during each sweep. Intermittent film motion is started at appropriately selected preset intervals, but stopped at the end of each 180° scan. A wedge-compensated double-dove type prism equipped with masks provides uniform exposure to horizons.

Other design features that make the camera suitable for high-speed, low-or-high-altitude panoramic photography include: high resolution of 40 lines per mm on high-speed film; built-in light baffles; humidity seals and provision for flushing the scanning dome with dry gas to prevent fogging, and built-in safety features to prevent damage or fouling in case of power failure or faulty film.

Only 10.5 in. of film is used for each horizon-to-horizon picture. A feed system meters the exact amount of film needed.

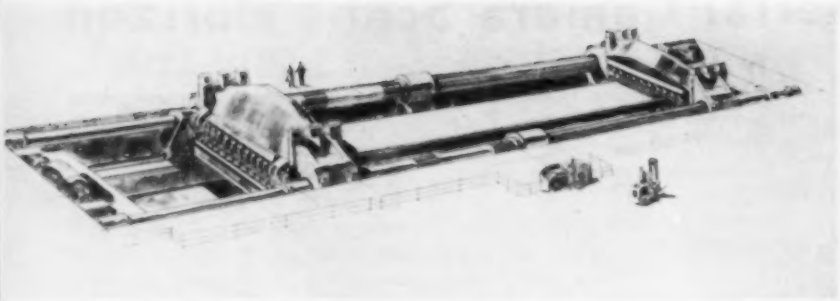
No More Clickety Clack Echoing Back?

ALBANY, N. Y.—Gluing rail lengths together with a resin plastic is how Delaware & Hudson Railroad hopes to eliminate the noisiness of its car wheels.

According to John F. Hiltz, D-H vice-president, the special adhesive has been applied to a one-mile stretch of connecting rail near Schenevus, N. Y., as substitute for continuous welding.

Such welding eliminates the click-ety-clack caused by train wheels passing over spaces left open for expansion or contraction. But welding is expensive and poses problems in repairing or relocating tracks.

The railroad's officials will await results of this first experiment, conducted under various climatic conditions, before applying for a patent and extending the gluing program to other sections of the line.



Pulling power . . .

of this aluminum plate stretcher is rated at 30,000,000 lb. It will go into Kaiser Aluminum's increased facilities at Ravenswood, W. Va.

Kaiser Orders Super-Strong Plate Stretcher

CHICAGO, ILL.—A 30,000,000-lb plate stretcher with double the power of the largest stretcher now in use is being built in Germany for Kaiser Aluminum's rolling mill at Ravenswood, West Va., where the company is already cold-rolling light-gage sheet and foil.

Capable of gripping the ends of a 60 ft-long plate of high-strength aluminum alloy and lengthening it by as much as 5 ft, the stretcher will handle a maximum cross-section of 640 sq in.; and take thicknesses up to 6 in. and widths up to 160 in.—in lengths from 17 to 60 feet. Together with associated heat-treating and ultrasonic testing equipment, the stretcher will help meet the aircraft industry's increasing demand for larger and thicker plate in the strongest aluminum alloys.

Scheduled for delivery to the heavy-plate section of the Ravenswood mill by 1959, the unit will be installed in a pit 120 x 15 ft without a guiding frame, free to move on foundation-supported tracks. Each head will be supported on each side by eight standard railway car wheels on a double track.

Instead of with conventional C-frame design, the top and bottom heads will be held together by six tie-bolts 15 in. dia and 15 ft long to provide for more effective jaw arrangement. A sytsem of shock absorbers and hydro-pneumatic recoils absorb the forces that would be released should a plate break while being stretched to capacity.

Hydraulik GMBH of Duisburg is building the stretcher to Kaiser's specifications.

Design of the stretcher has been conducted by Kaiser's Advanced Engineering Design Div. directed by A. Dean Smith. Kaiser pioneered in production of such plate with a 10,000,000-lb stretcher at its Trentwood, Wash., mill.

Target Drones Aim At Sound Barrier

POINT MUGU, CALIF.—The race to crack the sound barrier is on among designers of target drones needed by the military. Temco Aircraft Corp. of Dallas, Tex., has become a strong contender for the lead.

Effectiveness of its design was demonstrated in tests of its XKDT-1 drone here last week. The drone was carried aloft by an F3H-2M Demon Fighter, and launched from beneath its wing at an altitude of 20,000 ft. Using its own solid-propellent fuel, the target then flew a straight course for eight minutes.

The XKDT-1 was designed to operate near the speed of sound at altitudes up to 50,000 ft. It is 12 ft long, with 58.8-in. wing span and 10-in. body diameter.

Development of the drones is being spurred by military need for fast, cheap, expendable targets to test the effectiveness of air-to-air missiles and other defensive devices.

COMING EVENTS

OCTOBER

7-9....Joint Conference on Lubrication sponsored by ASME-ASLE. Royal York Hotel, Toronto, Canada.

7-9....National Electronics Conference, Hotel Sherman, Chicago, Ill.

7-11....American Institute of Electrical Engineers. Fall general meeting, Hotel Morrison, Chicago, Ill.

9-11....Society for Experimental Stress Analysis, Annual meeting at Hotel El Cortez, San Diego, Calif.

10-11....National Noise Abatement Symposium, Hotel Sherman, Chicago, Illinois.

10-11....SPI, New England Sectional Conference. Wentworth-by-the-Sea, Portsmouth, N. H.

10-12....Joint ASME-AIME (fuels division). Chateau Frontenac, Quebec, Canada.

13-17....Pressed Metal Institute. Annual meeting. Castle Harbor Hotel, Bermuda.

14-18....International Industrial Development Conference sponsored by Time-Life International and Stanford Research Institute. Fairmont Hotel, San Francisco, Calif.

16....Society of the Plastics Industries, Cellular Plastics Division. Commodore Hotel, New York City.

16-18....IRE Canadian Convention. Automotive Building at Exhibition Park, Toronto, Ontario.

16-18....American Society for Quality Control, 11th annual conference. Stratfield Hotel, Bridgeport, Conn.

17....Society of Plastics Engineers. Regional technical conference. Hotel Carter, Cleveland, Ohio.

17-18....National Conference on Industrial Hydraulics, sponsored by Armour Research Foundation and Illinois Institute of Technology. Hotel Sherman, Chicago.

17-18....Magnesium Association, annual conv. Biltmore Hotel, N. Y. C.

18-19....Professional Engineers of Oregon, convention. Eugene Hotel, Eugene, Oregon.

21-23....ASME National Power Conference, Americus Hotel, Allentown, Pa.

22....Association of Consulting Chemists and Chemical Engineers. annual meeting. Belmont Plaza Hotel, New York, N. Y.

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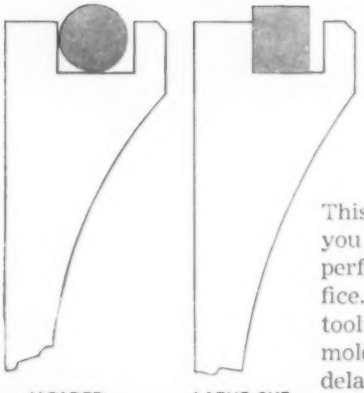
can save you money in *STATIC* or *MOVING* seal applications



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Patented Maxitorq Separator Springs that prevent drag, abrasion, and consequent heating in neutral . . . and the Maxitorq Locking Plate which locks all discs onto body . . . give you the outstanding features that are so highly favored by machine and product designers.

Thus you may build your own clutch or brake from our standard stock Maxitorq parts. The Disc-Pac keys to your shaft and is easily replaced. Units are available in 8-disc diameters from 2" to 8"; ¼ to 15 h.p. at 100 r.p.m. . . . with 3 lugs on the smallest size, 8 lugs on the 3 h.p., and 12 lugs on the 5, 10 and 15 h.p. capacities.

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Manchester, Connecticut

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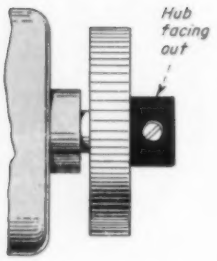
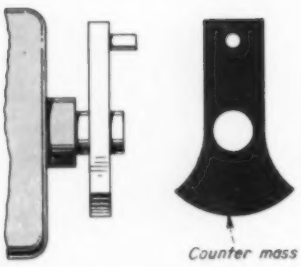
WALTER STRAND, *Vice-president, Merkle-Korff Gear Co.*

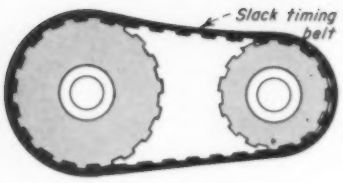
13 WAYS TO COUPLE FRACTIONAL-HORSEPOWER



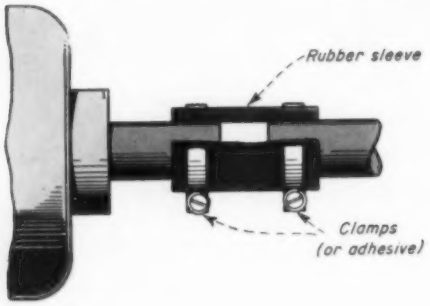
1 Gear hub facing away from motor . . .
prevents excessive bearing loads caused by too much overhang.



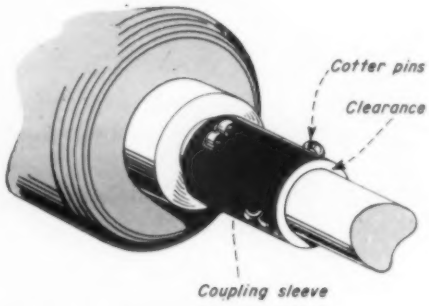
2 Counter mass gives static balance . . .
to driving attachment. Dynamic unbalance can still exist but is usually not large enough to cause trouble.



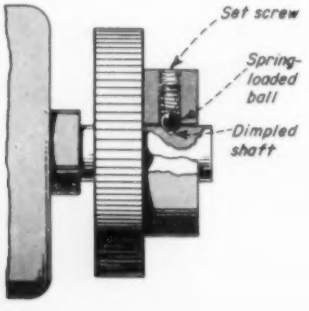
3 Slack timing belt . . .
insures positive drive without excessive tension. Plain belt may be used when deliberate slippage is desired to prevent excessive torque.



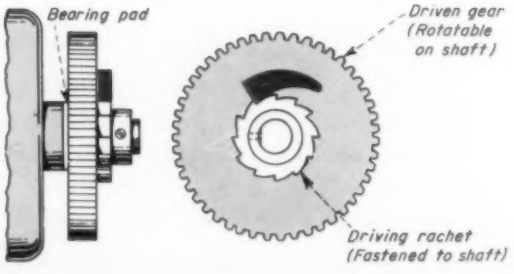
6 Rubber sleeve . . .
may not require clamp bands if shafts are tight fit. Resilient coupling is cheap and efficient. By varying hardness of rubber various degrees of mis-alignment can be tolerated. Vibrations are also isolated from motor or driven shaft.



7 Metal coupling sleeve . . .
gives flexible yet positive drive. Cotter pins 90° apart allow quick assembly. ID of sleeve must have clearance over OD of shaft.



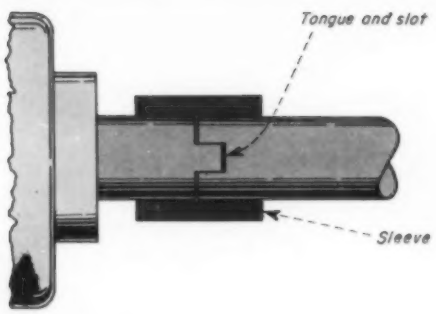
10 Torque limiter . . .
uses spring pressure to hold steel ball in dimple or axial channel on shaft. Spring pressure can be adjusted by set-screw to allow shaft to slip at either high or low torques.



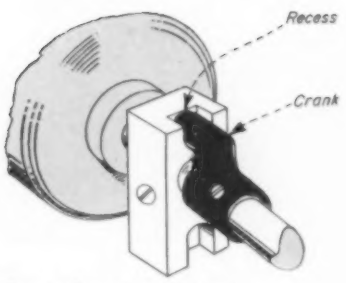
11 Ratchet and pawl . . .
provide simple over-riding clutch. Spring biases pawl toward ratchet. Backlash will depend upon ratchet pitch; one way of reducing backlash is to employ multiple pawls.

MOTORS

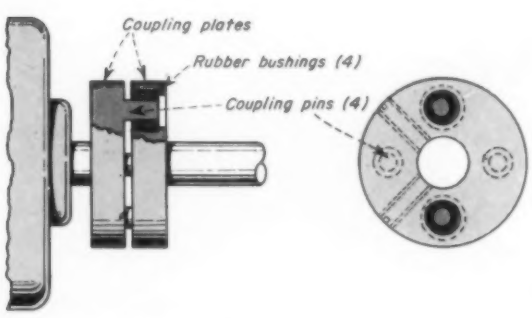
DESIGN ROUNDUP...



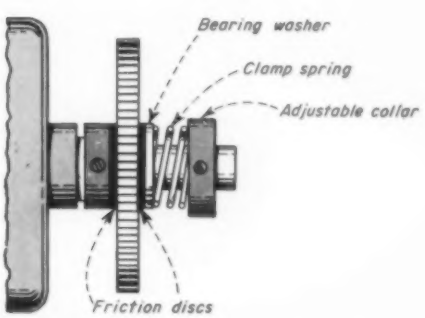
4 In tongue-and-groove drive . . .
coupling requires no separate fastenings such as set-screws or clamps. Drive should have enough clearance all around to allow for shaft misalignment and axial expansion or movement. Sleeve holds part in line when motor acts as one of shaft bearings.



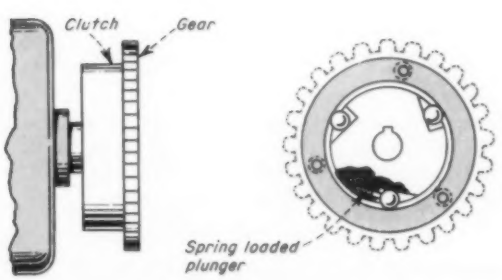
5 Crank and recessed hub . . .
provides flexible coupling that does not require any machining of shafts such as in tongue-and-groove method. Attachments may be of different materials to reduce friction or wear caused by badly aligned shafts.



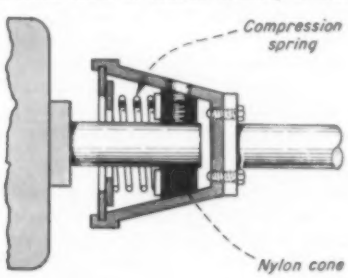
8 Four coupling pins . . .
two die-cast in each plate fit into resilient bushings in the mating plate to make a compact, vibration-insulated drive.



9 Friction disks . . .
clamping large gear or pulley prevent excessive torque on reduction-drive gearing in motor if large external gear is turned manually while motor is stopped. Also torque is limited in shock loads or sudden braking of driven shaft.



12 Infinite-grip clutch . . .
has zero backlash together with extremely free-running over-ride. Spring-loaded plunger insures instantaneous grip when driving torque is applied.



13 Friction drive . . .
attached to motor shaft by setscrew in nylon cone can be designed to slip at various torques. Varying the force between the two cones changes slipping torque. Torque of 8 lb-in. is one example of setting.

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- adequate terminal clearances for easy wiring.
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- fully independent twin contact springs.
- sturdy, strain-relieved heelpiece insures stability of adjustment.

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Torsional Strength of Shafts

Formulas and charts for horsepower capacity of shafts from ½ to 2½ in. dia. and 100 to 1000 rpm.

For a maximum torsional deflection of 0.08° per foot, shaft length, diameter and horsepower capacity are related in

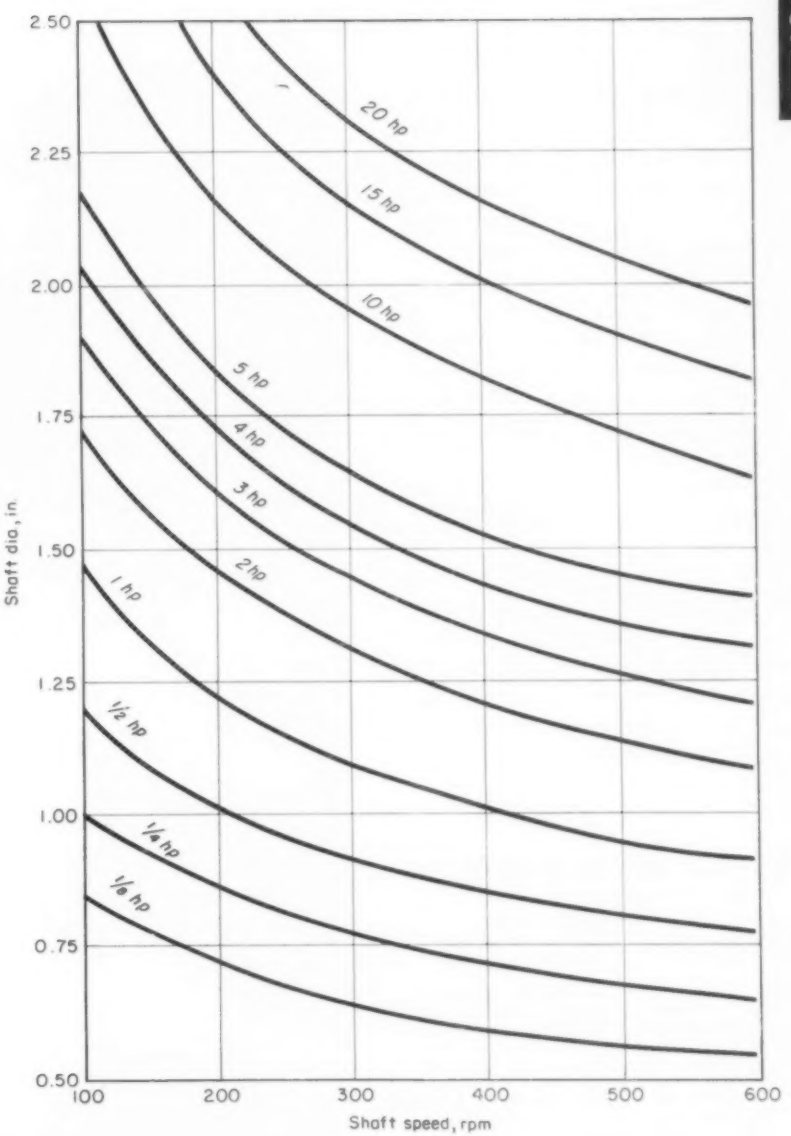
$$d = 4.6\sqrt[3]{\frac{hp}{R}}$$

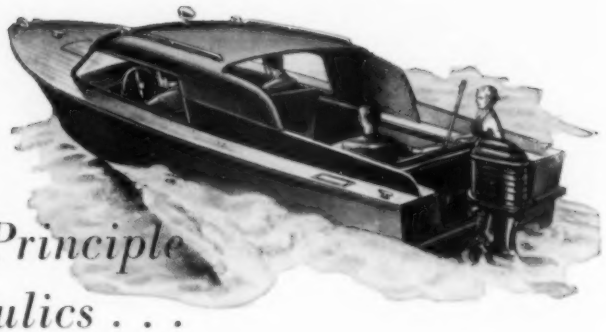
where d = shaft diameter, in.; hp = horsepower; R = shaft speed, rpm. This deflection is recommended by many authorities as being a safe general maximum. The two charts are plotted from this formula, providing a rapid means of checking transmission-shaft strength for usual industrial speeds up to 20 hp. Although shafts under 1-in. dia are not transmission shafts, strictly speaking, lower sizes have been included.

When shaft design is based on strength alone, the diameter can be larger than values plotted here. In such cases use the formula

$$d = \sqrt[3]{\frac{k\,hp}{R}}$$

(Continued on page 125)





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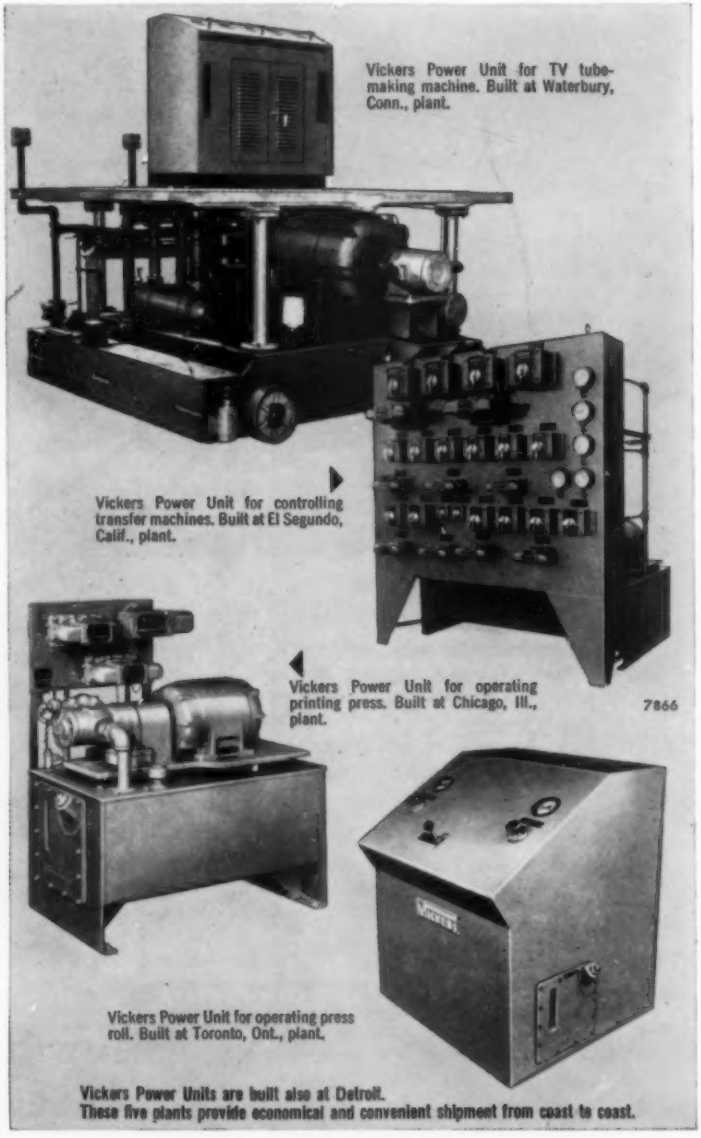
Vickers Power Unit for TV tube-making machine. Built at Waterbury, Conn., plant.
Vickers Power Unit for controlling transfer machines. Built at El Segundo, Calif., plant.
Vickers Power Unit for operating printing press. Built at Chicago, Ill., plant.
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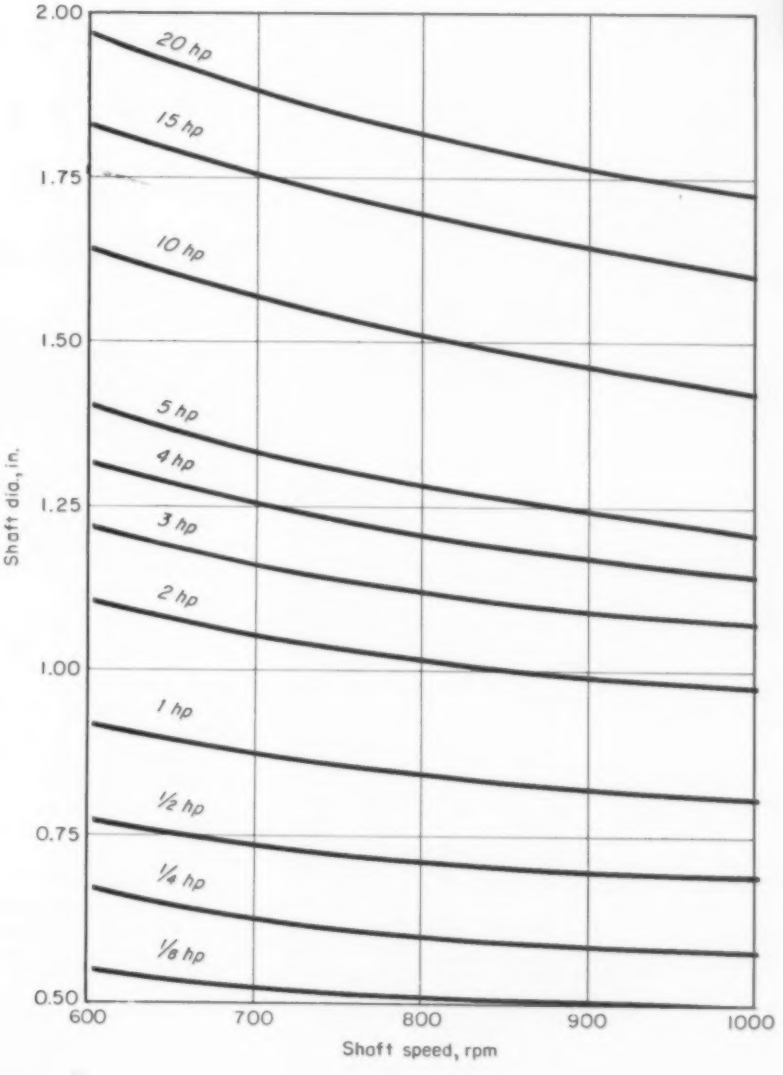
ENGINEERS AND BUILDERS OF OIL HYDRAULIC EQUIPMENT SINCE 1921

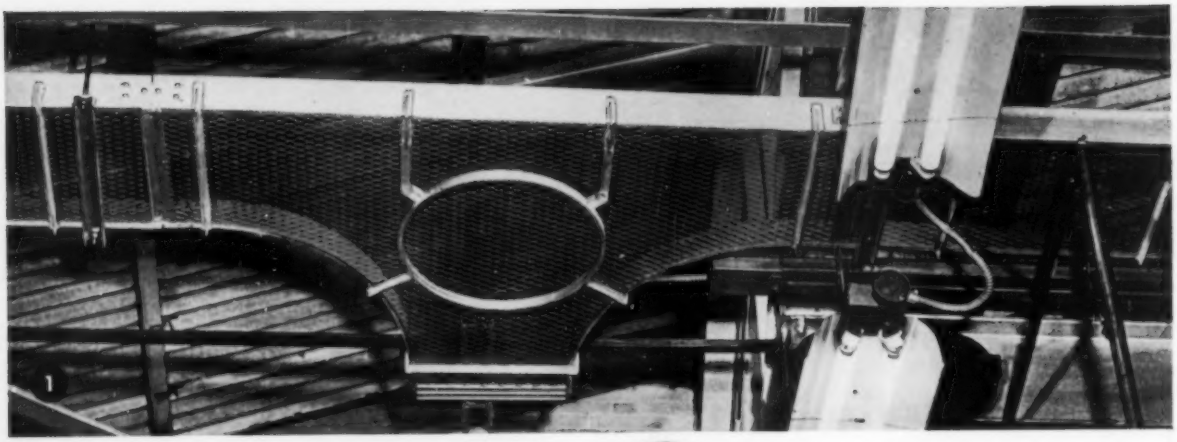
Torsional Strength of Shafts *(continued)*

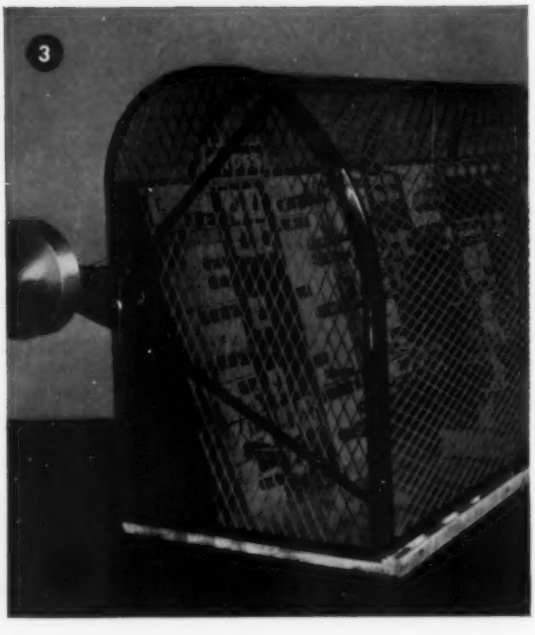
k	LOADING CONDITION
125 (2600 psi)	Head shafts subject to heavy strains. (Intermittent loads and slow speeds, clutches or gearing carried)
100 (3200 psi)	Lineshafts 75–100 ft long, heavily loaded. Bearings 8 ft apart.
90 (3550 psi)	Lineshafts 50–75 ft long, medium load, bearings 8 ft apart.
75 (4300 psi)	Lineshafts 20–50 ft long, lightly loaded, bearings 8 ft apart.

The value of k varies from 125 to 38 according to allowable stress used. The figure accounts for members that introduce bending loads, such as gears, clutches and pulleys. But bending loads are not as readily determined as torsional stress. Therefore, to allow for combined bending and torsional stresses, it is usual to assume simple torsion and use a lower design stress for the shaft depending upon how it is loaded. For example, 125 represents a stress of approximately 2600 psi, which is very low and should thus insure a strong-enough shaft. Other values of k for different loading conditions are shown in the table.

When bending stress is not considered, lower k values can be used, but a value of 38 should be regarded as the minimum.







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2. Corrosion-resistant grille for permanent heating or air-conditioning unit filter—made by Hadley Products Co., Inc., Marietta, O.

3. Strong, open-mesh guard for control and tool panel —Cross Company, Detroit, Mich.

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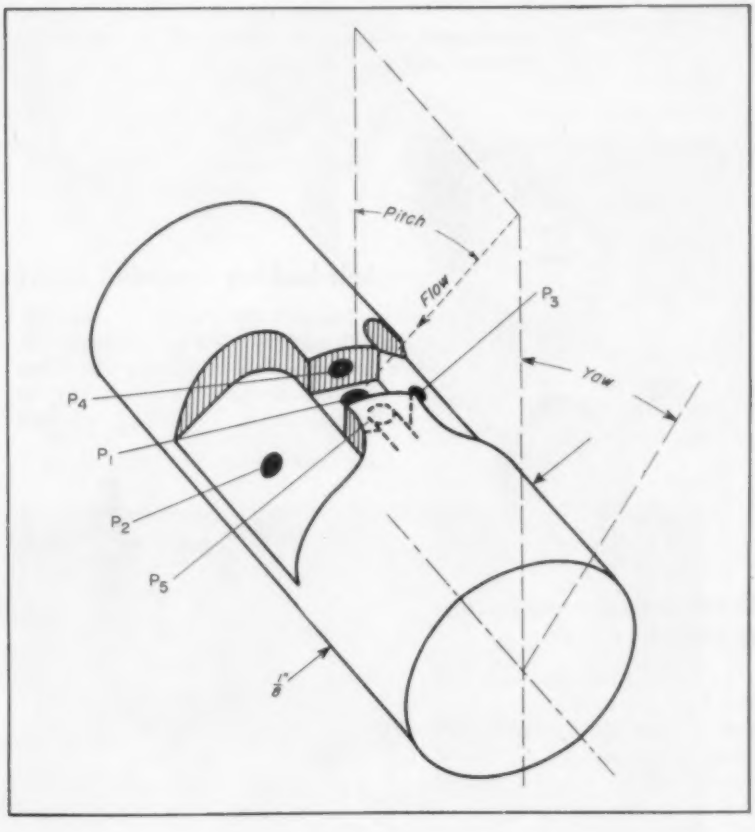
NEW COMPONENTS and MATERIALS



Direction and Velocity Sensing Probe

This miniature probe measures flow velocity, total and static pressure, and flow direction of liquids and gases in three dimensions (two independent direction angles). Calibration of the stainless steel instrument is constant at all velocities for liquids, but varies with Mach number for gases above Mach 0.25.

Six pressure holes, arranged in the probe direction-sensing properties, are recessed to minimize damage. Rotating the probe until pressures P_2 and P_3 (see drawing) are equal indicates the yaw angle of flow. P_1, P_2, P_3 and P_4 are then read. By finding three pressure ratios and referring to the calibration curves, total and static pressure and pitch angle are found.

Probes are available with a variety of stem lengths and take-off adapters, silver-soldered for use up to 1000 F or welded for use to 1500 F. The smallest fits through a $\frac{1}{8}$ in.-dia hole; sizes up to $\frac{1}{4}$ in. are available.

This type has been used successfully in gas turbine development by taking traverses between rotor and stator blades to measure actual flow velocities and angles under operating conditions. It has also found numerous applications in mapping streamlines in elbows and inlet sections where the flow is not two-dimensional.

Price of a 12-in. model for three dimensional flow is $60. Others, as part of complete drive and indicating systems, may run to $1200. Delivery, two to six weeks. **Aerotech Specialties, Inc., Glastonbury, Conn.**

For more information—
Circle 1, inside back cover

Miniature Relay-Amplifier Combination

Operating on a 25-microwatt input signal, this relay needs no preamplifiers—its operating signal is actually the input signal to the magnetic amplifier. The relay can accept unfiltered d-c signals directly from a thermocouple, resistance bridge, photocell, synchro, or even the detector of a radio receiver. The 2-cu-in. unit is the size of an ordinary sensitive relay.

Excitation required is 26 v at 400 cps, with other voltages and frequencies available. Power consumption is a few milliwatts. Contacts are rated at 2 amp resistive load per contact, with configurations available up to double-pole, double-throw. Input signal impedance is a nominal 2500 ohm. The unit is packaged in a hermetically sealed steel can 1 x 1 x 2 in., with compression glass terminals and studs or other mounting arrangements. Operating temperature range is from −55 to +100 C. **Torwico Electronics, Inc., 1090 Morris Ave., Union, N. J.**

For more information—
Circle 2, inside back cover

Control Switch for Low-pressure Applications

This switch was designed for such applications as movement control of roll-type air filters, pressure regulation of gas boosters, and switch operation of dampers, blowers, and gas-fired heaters. For these and similar low-pressure control, safety or signaling applications, it can be mounted in

CONTINUED ON PAGE 128

any position; operation is not affected by vibrations.

It requires 1½ in. head room and fits into an area of 3½ by 7½ in. There is no flow through the sensing element, so the connecting tubing can be small as ⅛ in. ID.

Pressure, vacuum or differential pressure will operate the switch. Normal range is from 0.1 in. to 5 in. water, but other ranges can be provided. The make-and-break contacts are adjustable to any point within the unit's limits. Pressure difference required to actuate contacts may be set as low as 0.1 in. water. Contacts can be preset at the factory according to customer's specifications, or this adjustment can be made in the field.

Switch is designed for up to 110 v, ac or dc. Circuit is normally open to normally closed, as desired. Delivery about 3 mo. **Bachrach Industrial Instrument Co., 200 N. Braddock Ave., Pittsburgh 8.**

For more information—
Circle 3, inside back cover

Wrist-watch-sized Pump Rated at ½ hp

This miniature vane pump will deliver 1.04 gpm at 1000 psi and 10,000 rpm. Output is 0.6 hp, dia less than 1⅛ in., and weight 2.5 oz. The pump cartridge can be used with servo valves, miniature piston hydraulic motors, and fhp electric motors.

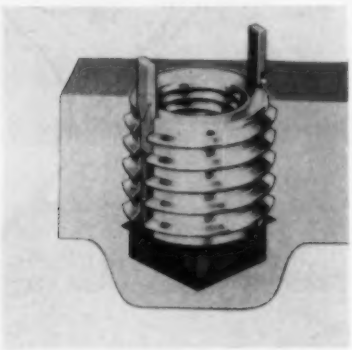
Hydraulic pressure balance provided by the pump's design is said to eliminate pressure-induced bearing loads. Optimum running clearances are automatically maintained by vanes and pressure plates.

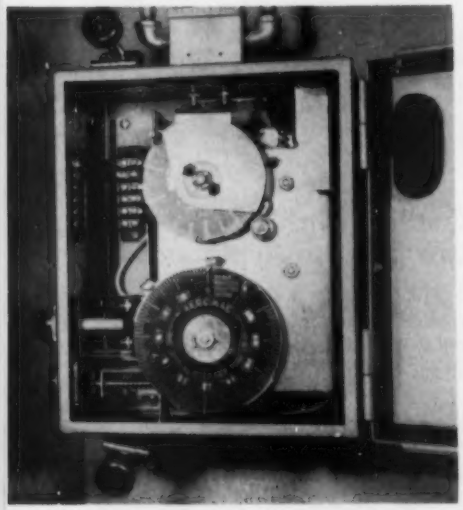
At present the pump is recommended for a maximum of 10,000 rpm at 1000 psi. Availability at least 90 days. **Vickers, Inc., Detroit, Mich.**

For more information—
Circle 4, inside back cover

Self-locking threaded insert

For bolt attachment in relatively soft materials, such as aluminum and magnesium alloys, and as a self-locking internal thread in a blind hole in harder metals. They are supplied





Combination Cam and Interval Timer

Originally designed for control of compression molding equipment, this timer is described as bridging the area where an ordinary interval- or single-cam timer suffices, and the area where cycle complexity justifies costlier equipment. For most applications cams or cam speeds need not be altered but provision for alteration is available. Motor gear and cam are interchangeable. These would be in addition to the slideable cam and cover segments. Cam-drive motors at various shaft speeds are available to give, together with the exchangeable motor gear on the timer, such time ranges as: 8 to 12 min, 4 to 1 min, 2 to ½ min, 1 to ¼ min, 32 to 8 sec, 16 to 4 sec.

The starting pushbutton is integral with the timer housing. It latches a reset type switch in the operating assembly. The resulting circuit runs both the cam-driving and the interval-timing motor.

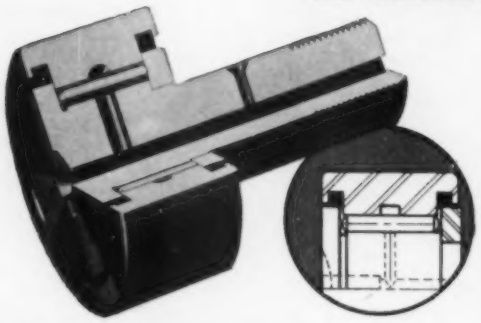
By multiple-level cam cutting, individual pilot valves or switches can be operated on separate schedules. Price range $205-270; delivery 6-8 wk. **Seely Instrument Co., 377 Fourth St., Niagara Falls, N. Y.**

For more information—
Circle 5, inside back cover

CONTINUED ON PAGE 130

BEARING TIPS by McGill

sealed CAMROL® bearings lock out contamination in critical cam follower applications

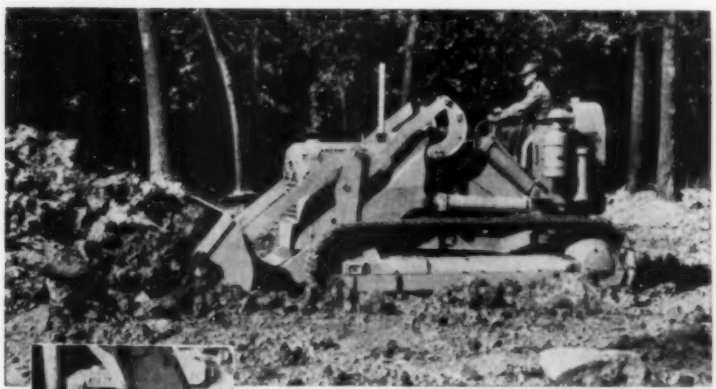


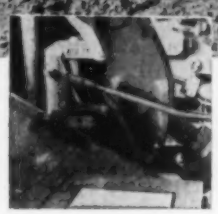
Now Sealed and Prelubricated

The new SCF series of the famous CAMROL cam follower completely seals out dirt, chips, moisture, etc. — an important advantage where the life of an ordinarily open mounted cam follower can be materially increased with adequate protection against contamination. Also the sealed bearing is pre-lubricated with provision made for easy re-lubrication, if desired, through either end of the stud.

Specially treated synthetic seals are contained in the outer race undercuts over the stud flange and roller retaining washer. For added protection, all external surfaces of the bearing are treated to provide a corrosion resistant, black ferrous oxide surface.

These same advantages are available in the SCYR sealed series Cam Yoke Roller (without stud). Specify CAMROL bearings with the built-in seals that preserve cam follower dependability in critical cam action, support or track roller application.





Built-in seals protect and preserve CAMROL® bearings from contamination in CATERPILLAR tractor-shovels

McGill SCF series sealed CAMROL bearings provide the cam action that positions the bucket of the 977 Traxcavator unit at the selected digging angle. Mounted on bell crank arms that are actuated by contact with a cam shoe on a hydraulic cylinder, these bearings are operating in the open and exposed constantly to dust, dirt and moisture. External surfaces have a black ferrous-oxide finish to prevent corrosion. These sealed McGill cam followers eliminate the need for relubrication and maintenance after installation. Caterpillar uses other McGill bearings including twelve CYR series cam yoke roller bearings in the flywheel clutch.

378 sealed CAMROL® bearings guide engine blocks in INGERSOLL automatic milling machine

The sealed CAMROL bearings used in this machine, guide cylinder blocks during transfer through various milling, boring and drilling operations. The bearings, used in place of guide bars, eliminate surface scratching of the 200 to 300 pound blocks which are transferred at speeds up to 400 feet per minute. Blocks are processed at the rate of 95 per hour. Ingersoll reports freer movement, accuracy of positioning and materially longer bearing life due to the new design that seals metal chips out of the bearings.

Insure performance with McGILL®

MULTIROL® GUIDEROL® CAMROL®
Precision Needle Bearings

McGILL MANUFACTURING COMPANY, INC., 201 N. LAFAYETTE ST., VALPARAISO, INDIANA

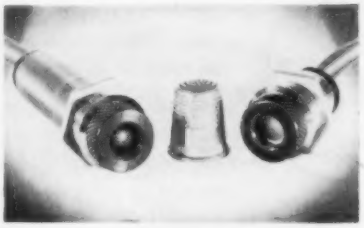
as one-piece, all-metal units, they can be screwed by hand into tapped holes prepared with standard drills and taps. Externally threaded along entire length for maximum pull-out resistance. Bolt is securely gripped after approximately one bolt diameter of thread engagement. Newton Insert Co., 6500 Avalon Blvd., Los Angeles 3, Calif.

For more information—
Circle 6, inside back cover

Custom meters . . .

with interchangeable range scales are offered in 2½, 3½, and 4½ in. rectangular, with shunting and multiplier resistors that permit coverage of more than 100 voltage and current ranges, ac and dc. Six meters cover the following ranges: dc, 100 ohm per v from 0.05 through 1500 v in 19 ranges; dc, 2000 ohm per v from 0.05 to 1500 v in 19 ranges; dc, 20,000 ohm per v from 0.1 through 1500 v in 19 scale faces; ac, 1000 ohm per v from 1 to 1500 in 17 ranges; dc, from 50 microamp to 1 amp in 15 ranges; ac, from 1 ma to 1 amp in 10 scale faces. Meters feature moving coil design, polished jewels and pivots, fatigue-tested springs and stress-released assembled units, within 2% accuracy. Precise Development Corp., Oceanside, N. Y.

For more information—
Circle 7, inside back cover



Miniature photoelectric projector . . .

can be mounted in a single $\frac{1}{16}$ in. dia hole and is designed for close-proximity use with miniature photoelectric cells. Operated on a nominal 0.15 amp input of 6.3 v ac or dc. Access to the base lamp is by removal of protective ring. Size is shown in relation to a thimble in the accompanying photo. Autron Engineering, Inc., 1254 W. Sixth St., Los Angeles 17, Calif.

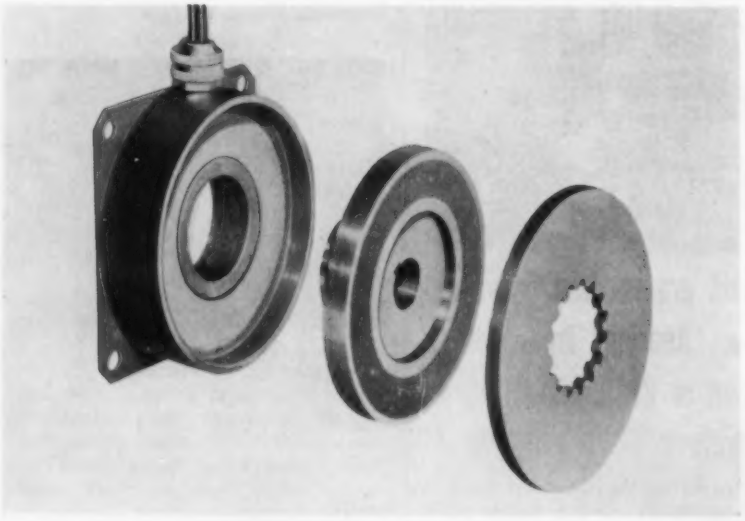
For more information—
Circle 9, inside back cover

Flexible printed cable . . .

permits weight savings of 4:1 for signal cable and 2:1 for power cable. Made of silicone rubber with or without glass reinforcement; shielding is available in the

cover coat. It can be produced in any length and various conductor patterns. Graphik Circuits Div., Cinch Mfg. Co., 200 S. Turnbull Canyon Rd., La Puente, Calif.

For more information—
Circle 10, inside back cover



Clutch with Stationary Magnet

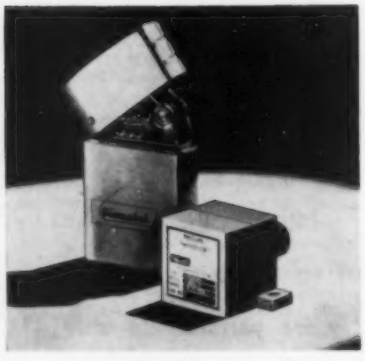
The three main parts of this clutch are magnet body, drive member, and driven member. It is manufactured in sizes from 1⅛ up to 5 in. dia, with torque ranges of 25 in.-oz. up to 170 in.-lb. All clutches are wound for direct current, with maximum ratings from 28 v on the smaller clutches to 90 v on the larger.

The stationary magnet is said to eliminate collector rings. Stearns Electric Corp., 120 N. Broadway, Milwaukee 2, Wis.

For more information—
Circle 8, inside back cover

Pressure transducer of 1 cu. in. . . .

weighs less than 3 oz. Has output to 50 v, which in most cases can be used directly without amplification. Available in pressure ranges from 0 to 15 psi to 0 to 50 psi, absolute, differential, or gage. A pressure capsule actuates, through a low-friction 7:1 multiplication mechanism, the brush of a potentiometer. Resolution of 0.33% (300 wires) is provided, with a



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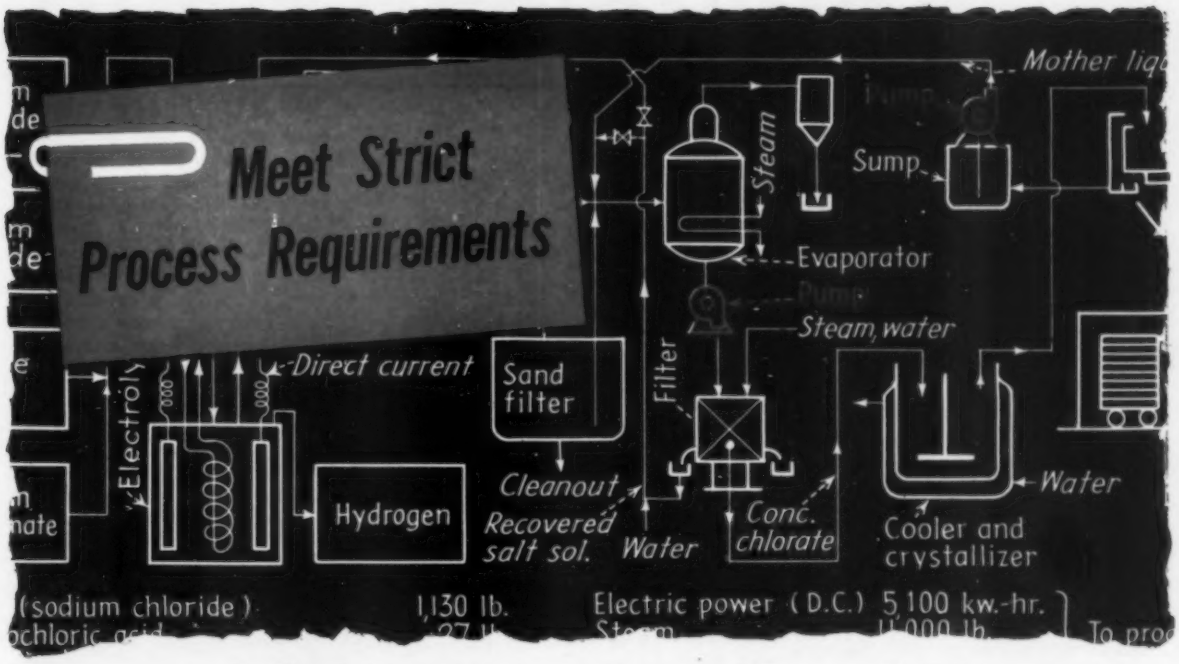
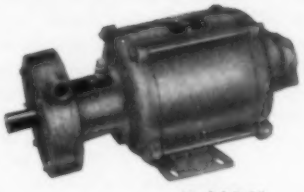


. . . with Eastern Centrifugal Pumps

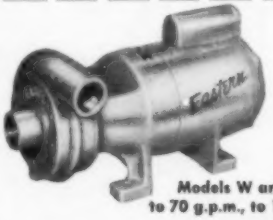
Models 2F and 2J
to 2 g.p.m., 25-42 p.s.i.



Model D-11
to 7.5 g.p.m., to 18 p.s.i.

Model F
to 17 g.p.m., to 17 p.s.i.

Models U-17 and U-34
to 38 g.p.m., to 21 p.s.i.



Models W and Z
to 70 g.p.m., to 11 p.s.i.

Models 3F and 3J
to 5 g.p.m., 29-65 p.s.i.

Recent redesign of these close-coupled Centrifugal Pumps has gained tremendous ruggedness and allowed for a wide selection of power requirements. In every detail of size, weight, space requirements, power, and costs, Eastern pumps fill the bill for strict process standards.

Six standard models range from 1/8th to 3/4 H.P., with capacities up to 70 G.P.M., pressures to 65 P.S.I. Eastern Centrifugal Pumps are available in Cast Iron, Bronze, Stainless Steel, Monel, and Hastelloy "C".

Eastern's engineering service offers many special models to meet your specific needs as to capacity and construction. Recommendations entail no obligation, and your inquiries are invited.

NEW EASTERN CATALOG

Eastern Centrifugal Pump Catalog contains engineering data, performance charts, diagrams and helpful general information. Request Bulletin 110-B.

Eastern
INDUSTRIES, INC.
100 SKIFF ST.
HAMDEN 14, CONN.

linearity tolerance of less than 1.5% of full-scale output. Mounting, which can be directly at the pressure source, can be accomplished in a variety of ways: flange, stacking, strap mounting, or threaded pressure connector. G. M. Giannini & Co., Inc., 918 E. Green St., Pasadena 1, Calif.

For more information—
Circle 11, inside back cover

Condenser . . .

with magnetic-pneumatic action condenses out moisture and oil vapors, and filters out solid contaminants from compressed air and gas. Models M-30T and M-100T combine in one unit an internal condenser, disposal filter cartridge and automatic condensate discharge. A pilot-actuated, power-operated mechanism discharges the condensate. A pilot valve triggers a system-air-powered piston that opens and closes the main discharge valve. Trap has a maximum operating capacity of 13 gpm at 10 psig; 42 gpm at 100 psig; 60 gpm at 200 psig. Condensers have an operating capacity of 30 cfm and 100 cfm depending on the model, at 100 psig; operating pressures to 200 psig, max. Hankison Corp., 951 Banksville Rd., Pittsburgh 16.

For more information—
Circle 12, inside back cover

Indicating switch . . .

for 6, 12, and 28 v, in blue, red, green, white and yellow, projects less than 1 in. behind the panel and has a $\frac{3}{4}$ in. dia, max. Designed primarily for pulsing remote-controlled relays and indicating their operation. Gives light that can be seen at 180° and at a distance. Versatile electrical layout of the switch allows it to be wired as a momentary contact, pushbutton-style indicating switch or a press-to-test indicating light. Mounts in panels from $\frac{1}{16}$ in. to $\frac{7}{8}$ in. thick. Nylon insulation is used. Alden Products Co., Dept. TS-89, Brockton, Mass.

For more information—
Circle 13, inside back cover

Four-digit stroke counter . . .

counts to 9999. One turn of the knob resets to zero. Enclosing cover is die-cast with chrome-plate finish. Mounting holes prevent disassembly for tampering without complete dismounting. Dial has white numerals on black ground. Available with rigid or spring-steel operating arm, top-coming or top-going arm action, right or

left shaft extension. Dimensions, less operating arm, $2\frac{43}{64}$ x $1\frac{33}{64}$ x $1\frac{23}{64}$ in. Production Instruments Div., General Controls Co., 8072 McCormick Blvd., Skokie, Ill.

For more information—
Circle 14, inside back cover

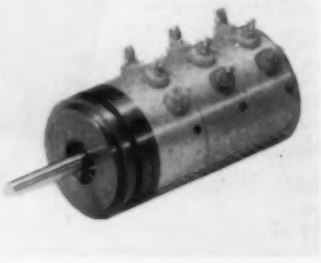
Ceramic relay . . .

for use under severe environmental conditions, operates satisfactorily during vibration of 25 G from 10 to 2000 cps, during 50 G and at ambient temperatures of 200 C without contact chatter. Contacts are in a vacuum surrounded by stacked ceramic enclosure. Three contacts in parallel in each switching circuit result in handling of inductive loads with peak inrush currents of 60 amp. Continuous rating of the contacts is 25 amp at 300 v. Relay is single-pole, double-throw or four-pole, double-throw. The latter is about the size of an egg and weighs about 1 lb. Jennings Radio Mfg. Corp., P. O. Box 1278, San Jose, Calif.

For more information—
Circle 15, inside back cover

Modular design potentiometers . . .

provide flexibility in customizing the standard design to the particular requirement. Available in subminiature, miniature and standard class with all types of mounting. This potentiometer is $\frac{1}{2}$ in. dia, has a resistance range of 50 to 100 k ohm, with 5% accuracy of total resistance and



2 w power rating. A larger model has a resistance range from 100 to 150 k, with a ± 5% (standard) and ± 1% (special) accuracy on linearity functions and a power rating of 2 w at 80 C. Operating temperature range of both units is —55 C to 145 C. Ball-bearing design makes possible a low torque that is less than 0.05 oz-in. per section. A complete range of sizes with modular design is available. Technology Instrument Corp., Acton, Mass.

For more information—
Circle 16, inside back cover

Size, position indicator . . .

features three calibrated ranges of ± 0.1 in., 0.01 in., and 0.001 in., full scale, with accuracy of 1% of scale. Drift errors are kept to a minimum by a constant current excitation system, stabilized amplifier circuitry and integral zero and gain checking features. Operates in temperatures from —65 F to 200 F. Auxiliary electrical output is available for direct operation of standard strip chart recorders. Wheel attachment is available for continuous thickness measurements of moving material. Price is $455. Daytronic Corp., 216 S. Main St., Dayton 2, Ohio.

For more information—
Circle 17, inside back cover

Gear motors, 1 to 10 hp . . .

and related transmissions have been developed in three basic components: an integral-type unit, with gear and drive motor packaged together; an all-motor-type that has the drive motor coupled to the gear reducer and mounted on a common carrier, and a separate helical speed reducer that can be used with a variety of prime movers. Mounting dimensions on all three are identical for similar rat-

CONTINUED ON PAGE 134

OVER-DESIGNING?

If you are designing bronze parts for mass production, there is a good chance that you are specifying a more costly alloy than you need.

ASARCO's patented continuous-casting process produces alloys according to SAE, ASTM and Government specifications. But their performance is entirely unlike that of similar alloys cast in sand or permanent molds. Relatively low-cost alloys cast by the ASARCO process perform like more expensive alloys cast by other methods.

For example, compare Continuous-Cast SAE 660 (ASARCON 773) with more expensive sand-cast alloys:

	Typical Yield Strength	Typical Impact Strength	Brinell Hardness
ASARCON 773	27,000 psi	12.5 ft.-lbs.	72
Sand-Cast SAE 62	20,000 psi	8.7 ft.-lbs.	65
Sand-Cast SAE 64	17,000 psi	8.2 ft.-lbs.	62

Unless you've checked to see whether the unique ASARCO bronzes can give you what you need, there's a possibility that you're over-designing. You may even be able to replace aluminum and manganese bronzes with low-cost ASARCON Continuous-Cast bronzes under certain conditions. Over-designing can be expensive in mass production, even if you are spending only a penny or two extra per pound of bronze.

ASARCON 773 (SAE 660) is readily available from stock in a wide range of sizes. An added bonus is the fact that ASARCON 773 is exceptionally free-machining. Rods, tubes, and numerous "extruded" shapes up to 9 inches in diameter are cast to order by ASARCO in more than 20 alloys.

We'll be happy to send you a free booklet describing the process and the product.

Continuous-Cast Products Department

AMERICAN SMELTING AND REFINING COMPANY

Perth Amboy Plant, Barber, New Jersey • Whiting, Indiana

WEST COAST SALES AGENT: Kingwell Bros. Ltd., 457 Minna Street, San Francisco IN CANADA: Federated Metals Canada, Ltd., Toronto and Montreal

designed to give you

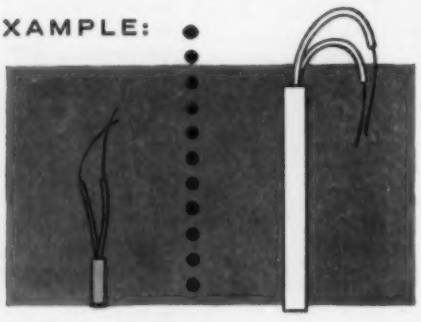
AS MUCH HEAT IN 1/5 THE SPACE!

NEW WATLOW FIREROD®

CARTRIDGE HEATING UNIT

a new high in watts densities and temperatures

FOR EXAMPLE:



The FIREROD can be rated at 368 watts/ sq. in. while operating in a steel block at 500° F. with a fit of .005. At this watts density, a unit 1/2" O. D. x 2-1/4" would have a rating of 1000 watts.

The Firerod gives you amazing concentration of heat in a small cartridge heating unit. So much in so little space means new design flexibility for many applications.

Units are available in lengths from 7/8" to 12", diameters of 3/8" and 1/2",

Pat. Pending

For convincing test-proof and other data, write for new FIREROD BULLETIN #360

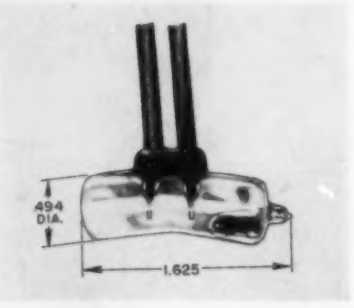
WATLOW

SINCE 1922—DESIGNERS AND MANUFACTURERS OF ELECTRIC HEATING UNITS

ELECTRIC MFG. CO.
1392 FERGUSON AVE.
SAINT LOUIS 14, MO.

ings and parts are interchangeable, permitting maximum stock flexibility. Speed reductions to be offered are single reduction offset shaft in speed ranges from 780 to 350 rpm; double reduction concentric shaft for speeds from 350 to 37 rpm, and triple reduction concentric shaft for output speeds from 30 to 13.5 rpm. Integral-type gear motors in ratings from 1 to 10 hp will be released on Oct. 1; others to 30 hp will be ready by Feb. 1, 1958. Initial release of helical speed reducers and all-motor gear motors will occur simultaneously with corresponding gear motor ratings. General Electric Co., Paterson, N. J.

For more information—
Circle 18, inside back cover



Mercury switch . . .

has positive pulse actuation with applications in business machines, call systems, counting devices, electric fences, inching circuits and other devices. Switch can be used for direct one-to-one revolution counting on slow rotating devices. High surface tension of mercury in the switch and double incline of the bent tube pull the mercury through the closed contact position without contact welding or dead break. Circuit always will be open, even if the driving mechanism fails to operate. Models are available with or without terminals and 7-in. lead wires. Circuit arrangement is single-pole, single-throw, momentary contact. Electrical rating is 1 amp resistive, 115 v, ac. Micro Switch Div., Minneapolis-Honeywell Regulator Co., Freeport, Ill.

For more information—
Circle 19, inside back cover

Three-position selector valve...

for use on lift trucks and similar applications. It can connect two hydraulic cylinders for simultaneous or individual operation. When the valve is in center position, fluid from the common inlet is directed to both outlets. When the spool is extended or retracted from center, the fluid is directed to either one cylinder or the other. Manually-operated detent mecha-

(Continued on page 138)

Synthane laminated plastics are at work

Synthane-covered tin plate rolls last three times as long as other materials because of resistance to acids and surface toughness.

Few industries escape the multiple benefits of Synthane laminated plastics. The food industry puts Synthane to work as star wheels for bottling equipment, bread slicing guides,as oil-less bearings in processing of sugar syrups and even in the tin-plating operation of metal containers.

Resistance to moisture, anti-friction characteristics, chemical and wear resistance are but a few of the reasons why Synthane is at work in this vital industry.

Synthane laminates combine in varying degrees—depending on which of the 30 or more grades you use—many mechanical, electrical and chemical properties hard to find combined in any other material.

You can buy Synthane in sheets, rods, tubes. If you prefer, your part can be supplied fabricated to your specifications. Send for our complete catalog for full information.

Synthane Corporation, 4 River Road, Oaks, Pa.

EASILY MACHINED

DIELECTRIC STRENGTH

CHEMICAL RESISTANCE

WEAR RESISTANCE

SYNTHANE ... industry's unseen essential.

SYNTHANE CORPORATION, 4 RIVER ROAD, OAKS, PA.

"Automation has raised our productivity to new high levels,"

reports a paper maker

Paper stock is automatically moved from this operation to the next by Jeffrey spiral conveyors.

JEFFREY
Spiral Conveyors

are a part of their automatically-controlled materials handling

• The high degree of automation recently introduced here has raised productivity per man to new high levels. Transfer of materials in process is largely under automatic control, for example, as evidenced by these Jeffrey spiral conveyor systems.

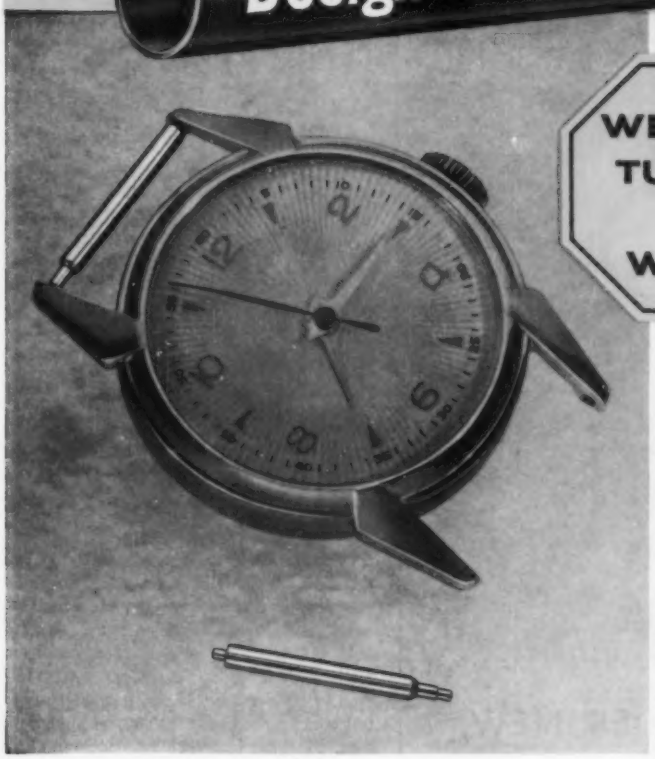
Jeffrey spiral conveyors offer an economical means of handling dry, loose bulk materials. Compact, they occupy a minimum of space. Convenient, they can be fed or discharged at any point along their length. Jeffrey makes them in open and dust-tight styles, of metals to suit particular requirements.

When adapting spiral conveyors to your products, ask Jeffrey engineers for their recommendations and assistance. Catalog 851 describes the various types available to you. The Jeffrey Manufacturing Company, 788 North Fourth Street, Columbus 16, Ohio.

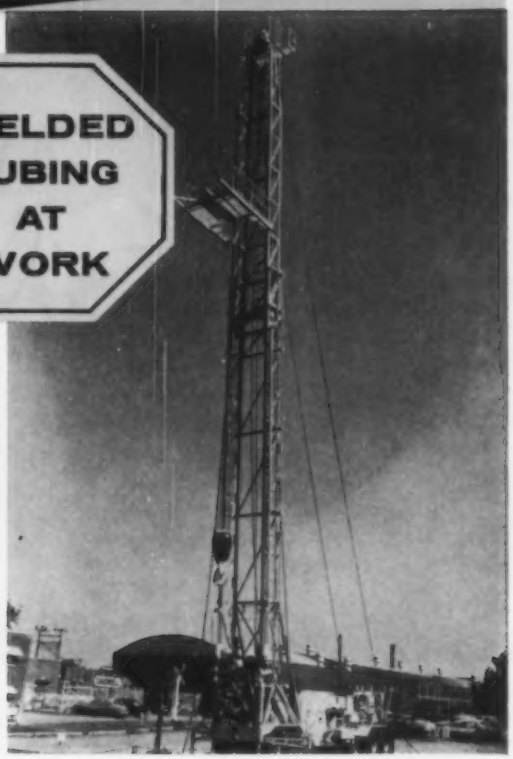
CONVEYING • PROCESSING • MINING EQUIPMENT...TRANSMISSION MACHINERY...CONTRACT MANUFACTURING

JEFFREY

Design with TUBING in mind!



WELDED TUBING AT WORK



Accuracy suitable for telescoping, strength for a vital service, corrosion-resistance to withstand body acids—all recommend Welded Stainless Steel Tubing for this tiny watch pin.

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The tubular form is one of engineering's most efficient sections—and Welded Tubing with greater uniformity about its axes is tubing at its best. Whether you have design requirements for great strength, light weight, high RPM, interchangeability of components, heat, pressure or corrosion—there is a size and grade of Welded Tubing to do your job best. For all tubing applications, consult a quality tubing producer.

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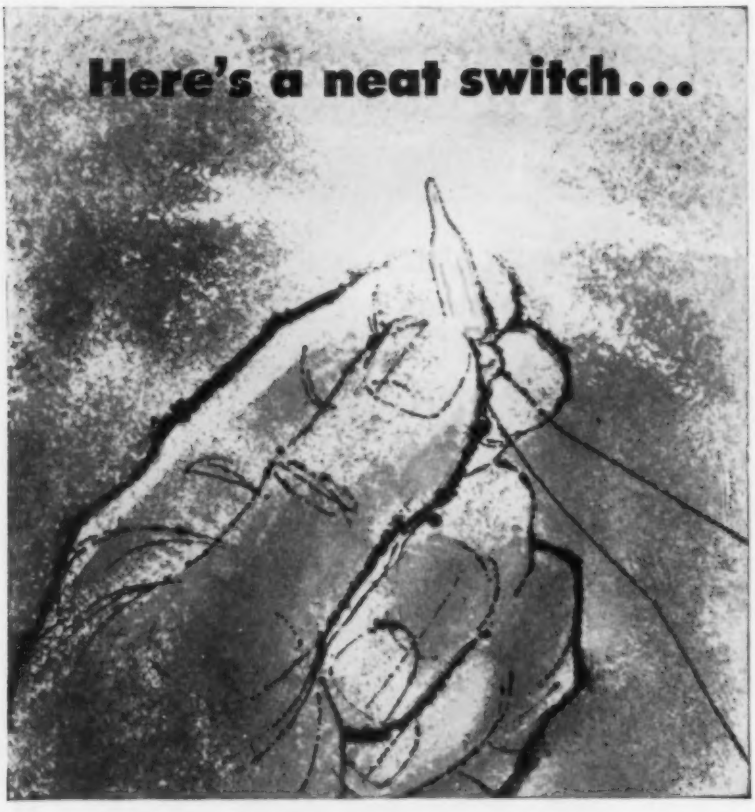

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Before a G-E Glow Lamp starts, it is essentially an open circuit. When the lamp is biased to a point just below its starting voltage, the application of a pulse sufficient to raise the applied voltage to that which is required for starting causes the lamp to conduct—and the pulse to be transmitted to the other components. Apply reverse pulse and the lamp is extinguished, the circuit broken.

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If you'd like more information on the amazing G-E Glow Lamps, send today for your free copy of the folder, "G-E Glow Lamps as Circuit Control Components". Write: General Electric Co., Miniature Lamp Dept. PE-97, Nela Park, Cleveland 12, Ohio.

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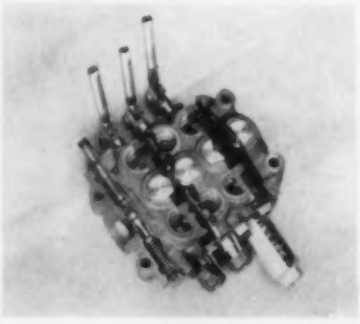
nism holds spool in any of the three positions. Ports are ½ in. NPT. No pressure relief valve. Mounted on the bracket as handle support. Size is 2 x 8.46 x 9.14 in. long. Char-Lynn Co., 2843 26 Ave., S., Minneapolis, Minn.

For more information—
Circle 20, inside back cover



Four-position control valve . . .
has a positive pilot-operated relief valve that permits setting to within a 50-lb max variation. This is said to make possible the use of horsepower engines often as much as 7 hp smaller than usual. Available with one through six plungers that are sealed at each end. Capacity is 35 gpm. Provides raise, lower, float and neutral control positions, with or without detent. Detent feature allows locking the plunger in any desired position, leaving the operator's hands free for other work. Individual checks are built into each circuit. Hydraulic Unit Specialties Co., P. O. Box 257-W, Waukesha, Wis.

For more information—
Circle 21, inside back cover

Directional control valves . . .
are engineered to provide excellent metering characteristics in raising, positioning, rotating, holding or lowering operations, and feature low-pressure drop. Open-center parallel circuit permits independent or simultaneous operation of two or more cylinders or hydraulic motors at one time. Available in one, two, three, four and six-spool models. Rated at 20 gpm capacity.

(Continued on page 142)

Here's Reliable Help for Users and Producers of

URETHANES

As a major producer of NACCONATES® (Diisocyanates), an essential basic material in all urethane formulations, NATIONAL ANILINE offers this practical assistance:

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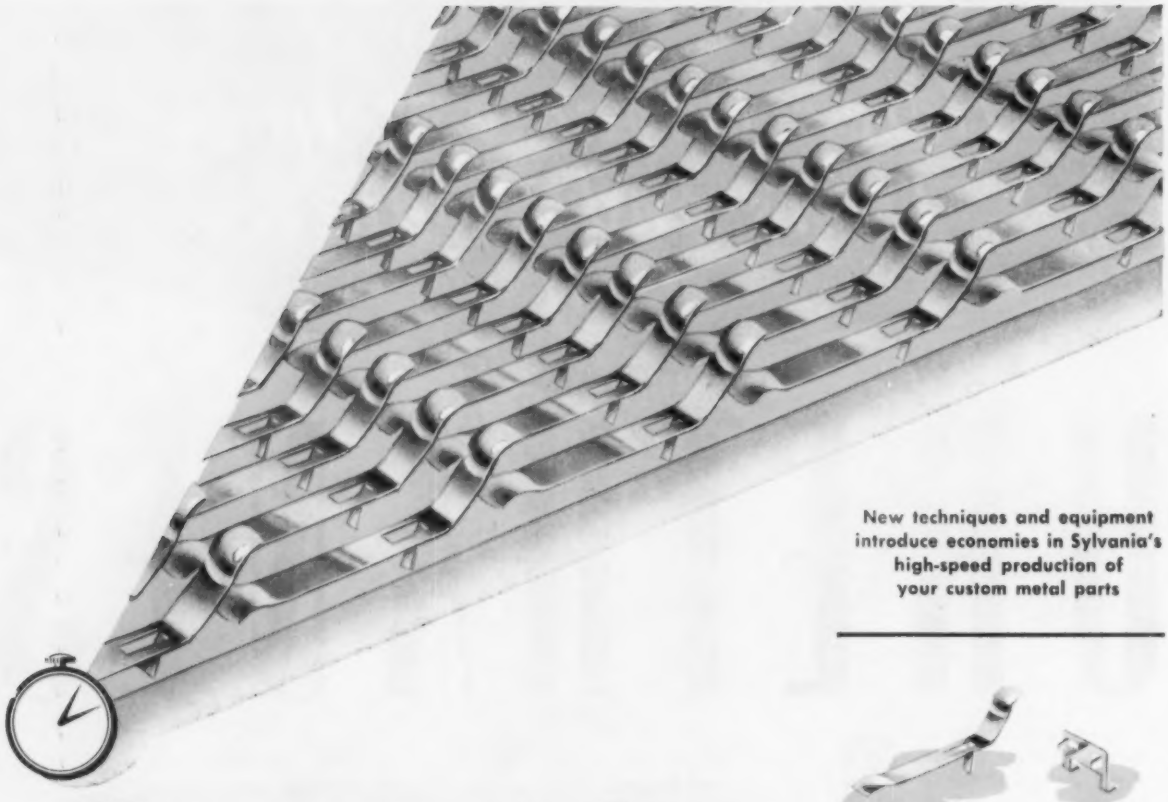

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More parts per hour

means lower cost per part

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57% increase from 7,000/hr. to 12,000/hr.

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33% increase from 6,000/hr. to 8,000/hr.

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Sylvania Electric Products Inc., Parts Division, Warren, Pennsylvania

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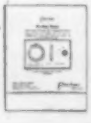

RUBBER PRODUCTS DIVISION, Section 525-CC
The Parker Appliance Company,
17325 Euclid Avenue, Cleveland 12, Ohio.
1538 South Eastern Ave., Los Angeles, Cal.

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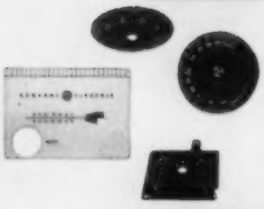

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USR RADIUM

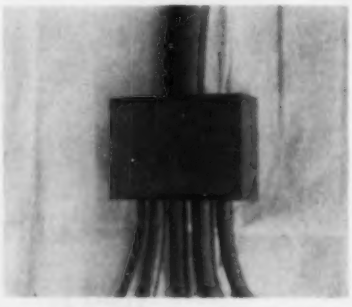
Operating pressure is to 2000 psi. Each spool has an individual check valve to prevent load drop when changing spool operating positions. An integral differential type relief valve operates quietly, has low pressure rise from crack to full flow, and is externally adjustable. Industrial Hydraulics Div., Parker Appliance Co., 17325 Euclid Ave., Cleveland 12, Ohio.

For more information—
Circle 22, inside back cover

Transistor clip . . .

designed for $\frac{5}{32}$-in. dia transistors working under severe shock, vibration, acceleration and deceleration conditions is made of beryllium copper. Available for use on printed boards or for mounting in place of tab. Plating is optional because the application may lend itself to using the beryllium copper as an added heat-dissipating feature. The clip has passed salt spray tests. Prestole Corp., 1345 Miami St., Toledo 5, Ohio.

For more information—
Circle 23, inside back cover



Breakout for multiconductor cable . . .

consists of split and bored metal plates that provide a clamping action on the cable jacket. Tension members between the clamping plates transmit any strain around the breakout junction to prevent undue stress on the wires within the junction. The entire mechanical structure is encapsulated. Pacific Automation Products, Inc., 1000 Air Way, Glendale, Calif.

For more information—
Circle 24, inside back cover

Matched bellows . . .

with tolerances on effective areas within 2% or less variation are being turned out in production quantities. Can be produced in stainless steel, Monel, brass, bronze, copper and a variety of alloys for any application where different forces acting simultaneously must be coordinated

(Continued on page 146)

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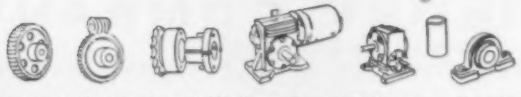

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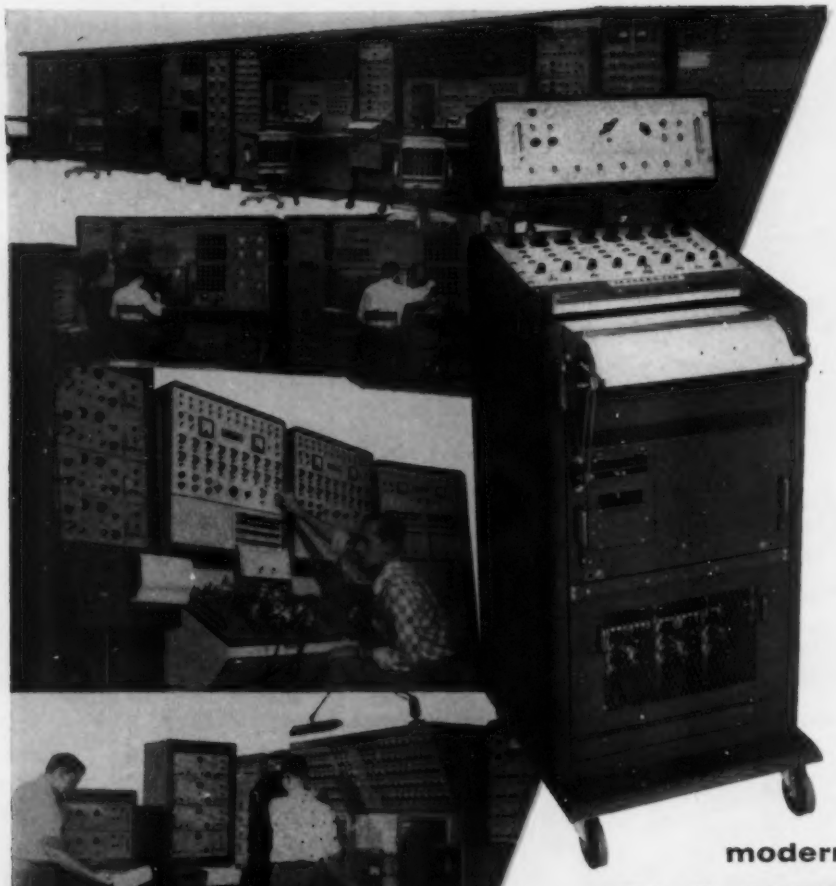

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analog computer
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SANBORN

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Up to eight problem variables can be recorded in inkless, permanent, rectangular-coordinate tracings – with Sanborn's improved six- and eight-channel 156-, 158-5490 Console Systems. Less than four feet high and about two feet in width and depth, these Systems are completely mobile and designed for maximum operating convenience. Controls and indicators on the sloping top panel include individual-channel attenuation, position, balance, sensitivity and stylus heat adjustments; switch for turning off B+ of output amplifiers; chart drive motor switch (can also be remotely controlled); code marker and/or one-second interval timer stylus switch. The Recorder unit, either six or eight channels, features paper loading from the top, and nine precisely controlled speeds from 0.25 to 100 mm/sec. Four dual-channel DC Driver Amplifiers of current feedback design are housed below the Recorder, and are mounted on a chassis which may be withdrawn for inspection.

Electrical specifications of the Console Recording Systems include a basic sensitivity of either .01 volt/chart division (5490 types) or 0.1 volt/chart division (5495 types); linearity of 1%; drift less than 1/2 chart division/hour (5490), less than 1/20 chart division/hour (5495); flat frequency response to 20 cps, down 3 db at 60 cps for all amplitudes to 5 cm peak; either single-ended or push-pull input signals of 5 meg. impedance (each input lead to ground).

A useful companion instrument is the new Sanborn Model 183 Programmer, designed to provide a connecting link between an analog computer and the Console Recording System. Shown mounted at the top rear of the Console, the Programmer operates the Console in the following automatic sequence: turns recorder drive on – feeds calibration signals to all channels – reads initial DC levels of computer – closes contacts to start computer problem – records computer output for a preset chart length – turns off recorder drive and resets itself for another cycle.

Further technical data, prices and delivery information — on the 5490/5495 Console Recording Systems and two- to eight-channel 5475/5480 Systems are available on request from your Sanborn Sales-Engineering Representative or the Industrial Division in Waltham.

40th ANNIVERSARY SANBORN COMPANY

SANBORN COMPANY
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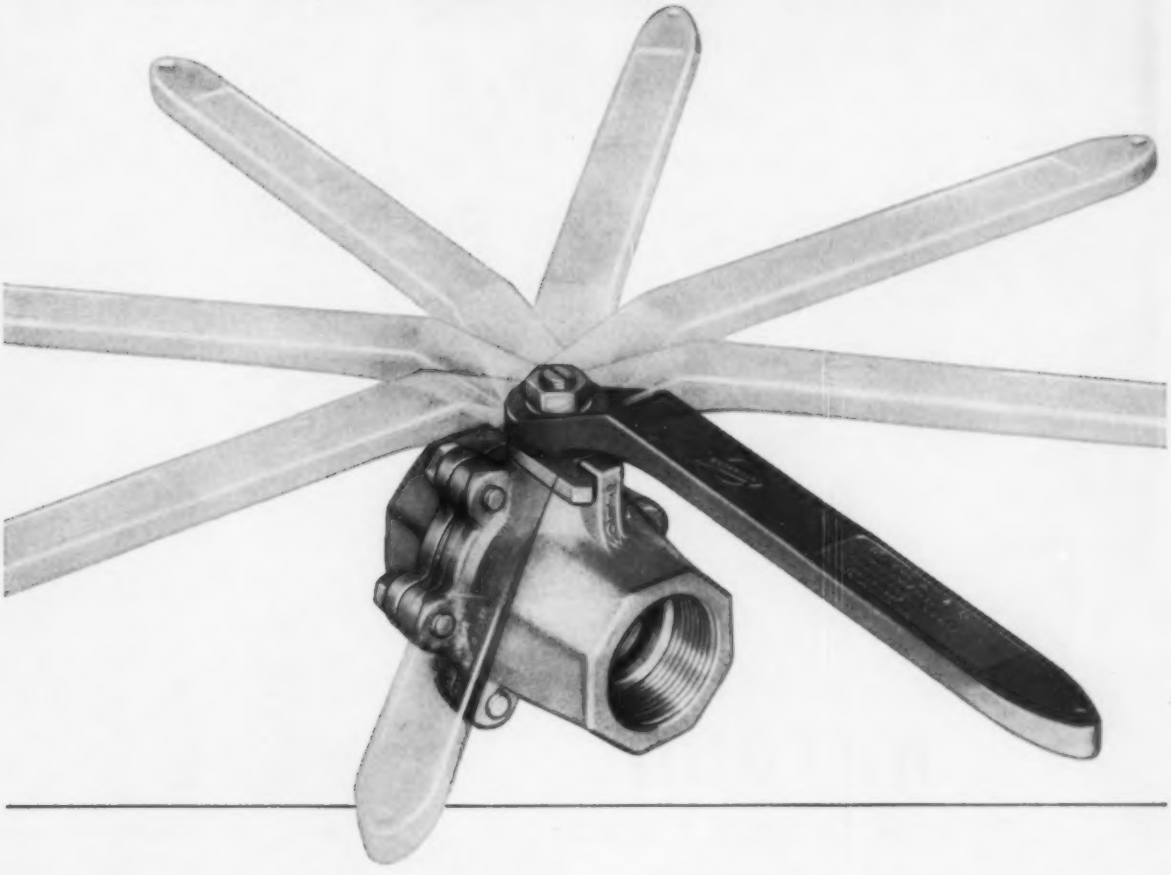
New Rockwood Forged Ball Valves

8 Ways Easier to Handle!



New Rockwood Ball Valves are made of forged brass for greater tensile strength and safety. You're assured of Full, Round Flow and fast, efficient operation and less friction loss too.

The handle of the new Rockwood Forged Ball Valve can be positioned in 8 different ways *giving you greater convenience.* The ¼ turn opens and closes the valve — *giving you Full, Round Flow, efficient operation, less friction.* The pressure of fluid in the Rockwood Forged Ball Valve automatically positions the ball against the synthetic rubber seat — *giving you a leakproof seal.* The forged brass ball in the Rockwood Forged Valve is chrome-plated to stand up under abrasion, pitting, scratching — *giving you trouble-free service.*

The new Rockwood Forged Ball Valve comes in pipe sizes from ⅜" to 2". Tested and listed by Underwriters' Laboratories, Inc. Mail the coupon now for complete specifications and information.

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For more information—
Circle 25, inside back cover

Flame-retardant glass epoxy laminate . . .

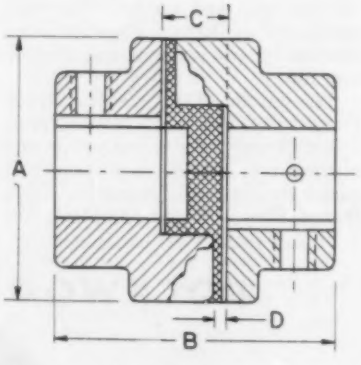
is heat resistant and can be used continuously at temperatures to 300 F. When removed from a flame, the laminate will not continue to burn. Available in plain form for power applications and metal clad for printed circuitry and in sheets ranging from 0.010-in. to 1 in. in thickness. Applications include panels and other electronic components requiring self-extinguishing characteristics. Continental-Diamond Fibre Corp., Newark, Del.

For more information—
Circle 26, inside back cover

Pressure-sensitive Teflon tape . . .

can be readily attached to metal, glass, plastic, and most other surfaces. The special silicone adhesive used will provide a firm bond with high peel strength at temperatures up to 500 F. Available in widths up to 2 in. in 36-yd rolls of 0.006-in. thickness and 18-yd rolls of 0.13-in. thicknesses. The tape can be used as an anti-friction surfacing and to provide dry lubrication of moving parts. Chicago Gasket Co., 1271 W. North Ave., Chicago 22, Ill.

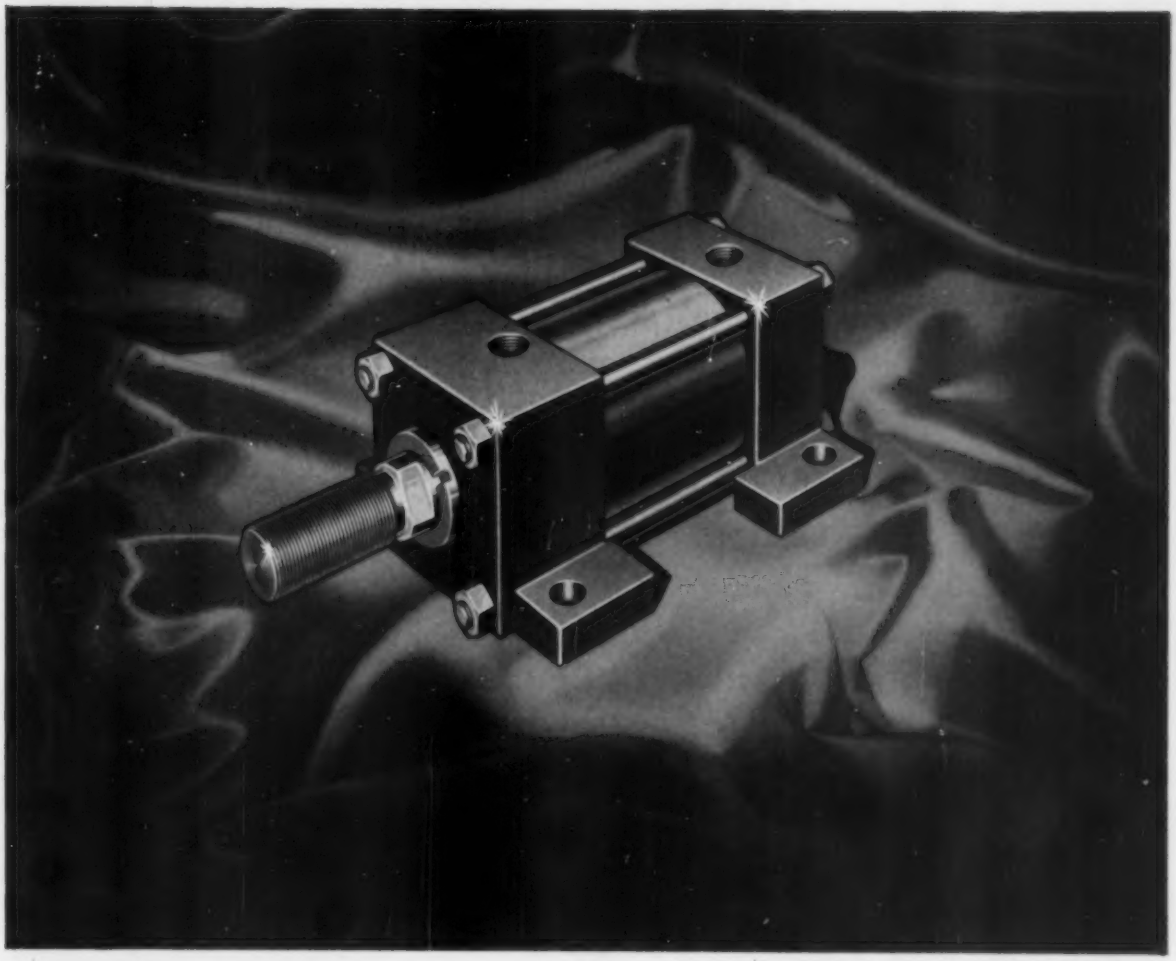
For more information—
Circle 27, inside back cover



Cast aluminum flexible coupling . . .

transmits load through cushion compression only. One-piece spider load cushion is lightweight, may be reversed for double

(Continued on page 150)



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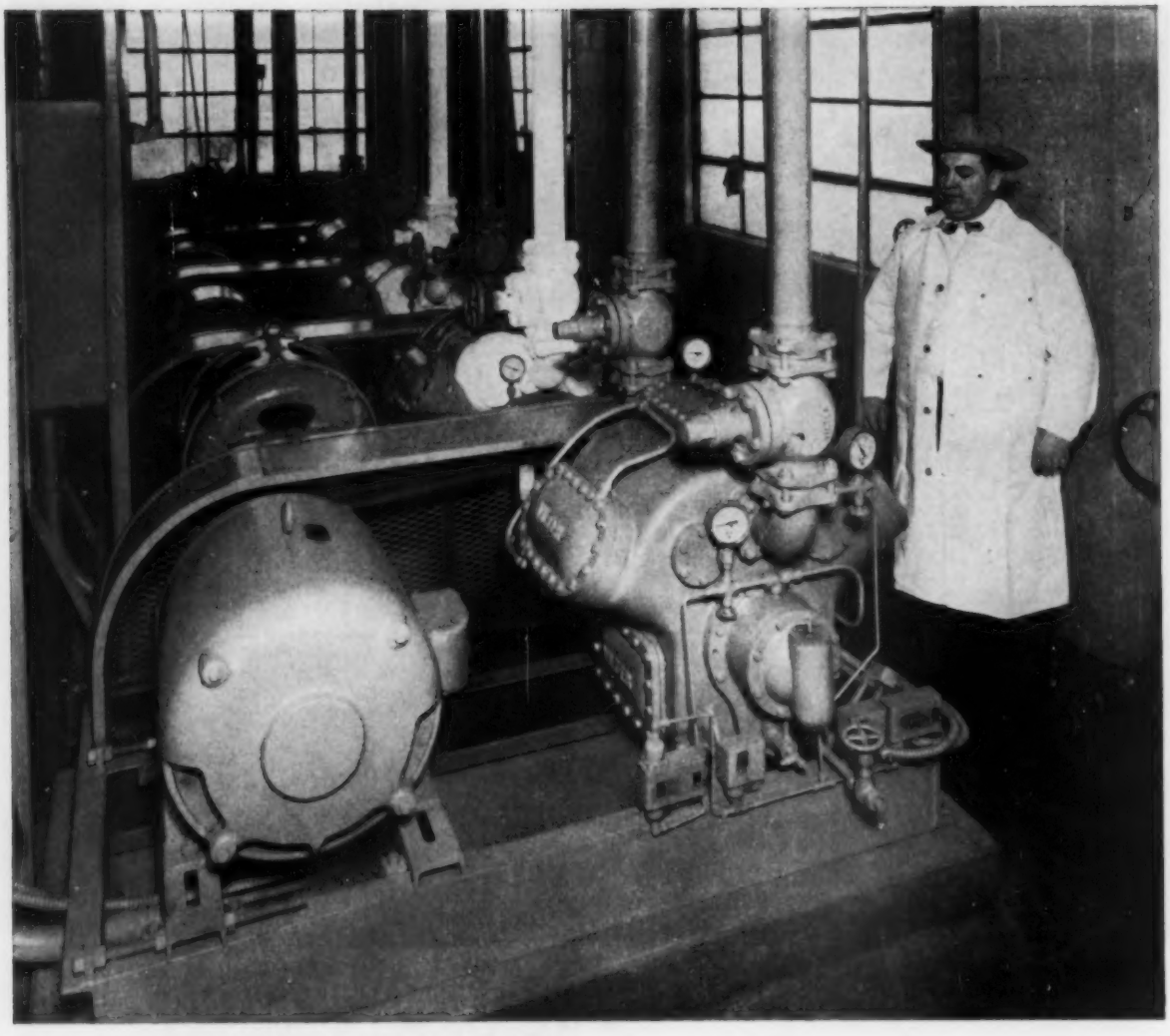

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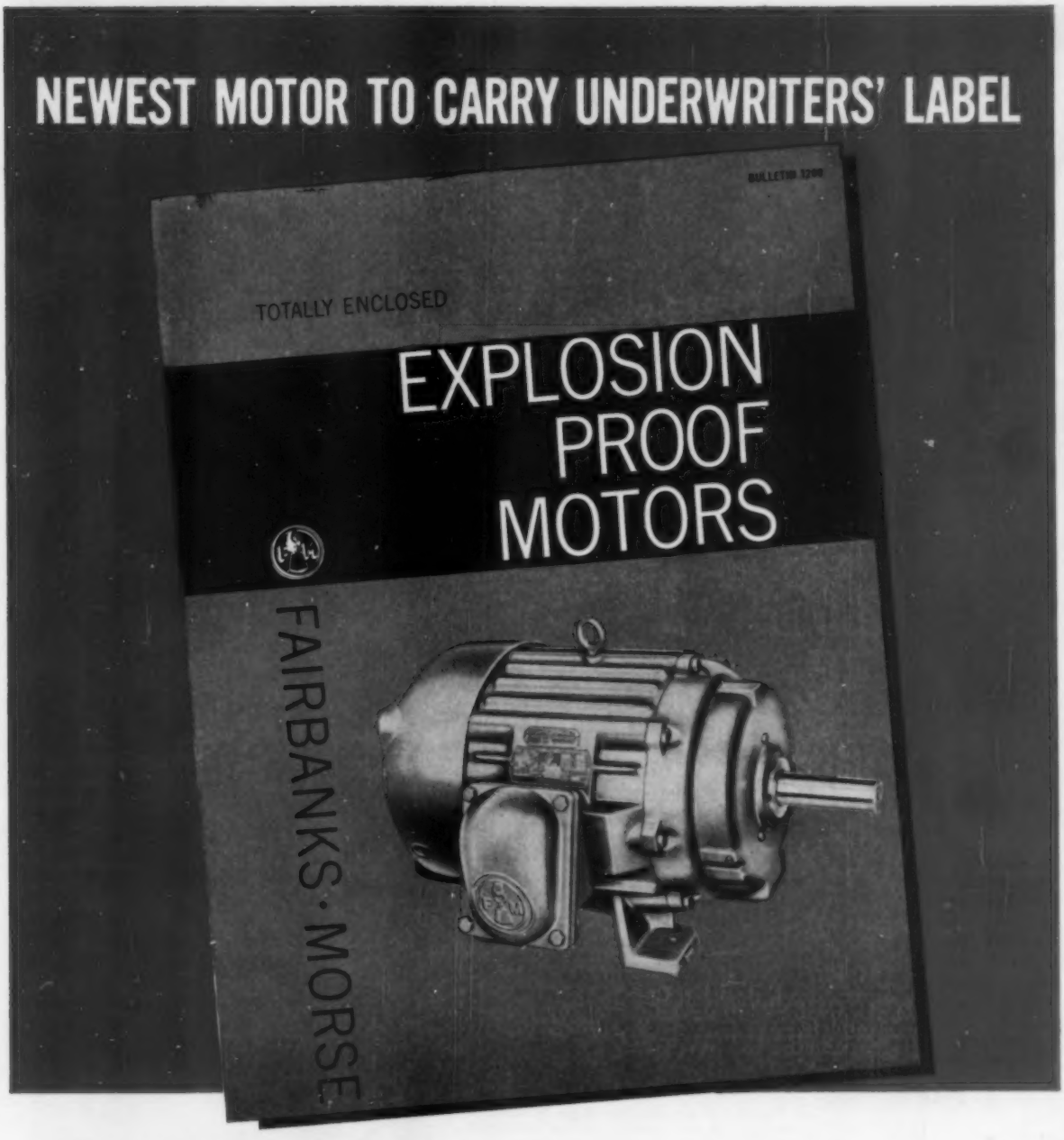

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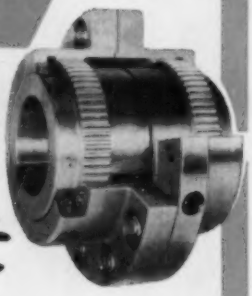

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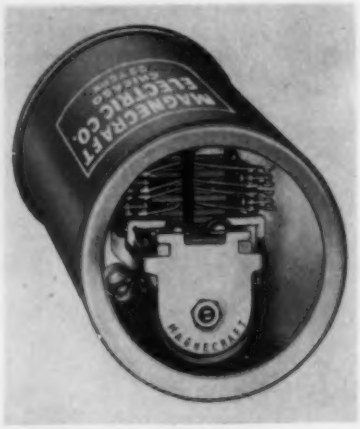
life, is plainly visible for quick inspection. No lubrication is required. Cushions are made from oak-tanned leather, Bakelite, or combinations of the two. Total weight is approximately ½ lb. Rated for loads of from $\frac{1}{70}$ hp at 100 rpm to 2 hp at 3600 rpm. Bore sizes range from ¼ to ⅞ in. in $\frac{1}{16}$-in. increments. Dimensions are 1¾ x 2½ in. Lovejoy Flexible Coupling Co., 4856 W. Lake St., Chicago 44, Ill.

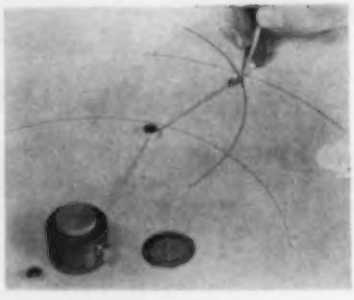
For more information—
Circle 28, inside back cover



Enclosed plug-in relays . . .

have plastic observation windows that permit visual inspection. Metal enclosures are dusttight. Currently available for a-c and d-c operation with contact combinations to six-pole, double-throw. Can be supplied with contacts ranging from bifurcated contacts for low voltage to power contacts rated 10 amp at 115 v a-c, non-inductive load. Magnecraft Electric Co., 3350Y W. Grand Ave., Chicago 51, Ill.

For more information—
Circle 29, inside back cover



Beam compass . . .

makes 12 in. circles, spirals, curves, and is controllable to a fraction of an inch. Pen, pencil or scriber is clamped in a socket at the end of a linen line and the reel can be anchored to the surface of

(Continued on page 154)

Steel-Weld FABRICATION

Use WELDED STEEL for Greater Strength with Less Weight!

The weldment illustrated above is the Cover Section of the housing for a 300,000 kw Steam Turbine . . . it weighs 55 tons. This unit and those shown at the left are typical of the thousands of Steel-Weld Fabricated parts and assemblies produced by Mahon each year for manufacturers of processing machinery, machine tools, and other types of heavy mechanical equipment. Are you taking full advantage of the economies offered by welded steel components in your products? In the design of almost any type of heavy machinery, or mechanical engineering project, there are parts and sub-assemblies that can be produced more economically and more satisfactorily in welded steel . . . because, in weldments you save time and pattern costs, and you get greater strength with less weight, plus the additional advantages of greater rigidity and 100% predictability. When you consider weldments, you will want to discuss your requirements with Mahon engineers, because, in the Mahon organization you will find a unique source for weldments or welded steel in any form . . . a fully responsible source with complete facilities for design engineering, fabricating, machining and assembling . . . a source where design skill is backed-up by craftsmanship which assures you a finer appearing product embodying every advantage of Steel-Weld Fabrication. See Sweet's Product Design File for information or have a Mahon sales engineer call at your convenience.

THE R. C. MAHON COMPANY • Detroit 34, Michigan

Sales-Engineering Offices in Detroit, New York and Chicago

Engineers and Fabricators of Steel in Any Form for Any Purpose

MAHON

ROBERT S. STEVENSON

Portrait by Fabian Bachrach

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"While this program has been going on for many years—made easy through the Payroll Savings Plan—we recently offered all Allis-Chalmers people a chance to review their individual bond purchasing schedules and to bring them up to date.

"As a result, more than 52% of the total Allis-Chalmers organization of about 40,000 people are buying U.S. Savings Bonds at a rate of approximately $6,000,000 a year."

ROBERT S. STEVENSON, *President*
Allis-Chalmers Manufacturing Company

Start your employees on the path of future financial security through automatic savings in the new and improved Series E Savings Bonds. It's simplicity itself. Just contact your State Director, U.S. Savings Bonds Division. He'll provide all the material and assistance you need to install a Payroll Savings Plan or build enrollment in one already existing. Look him up in the phone book or write for full information to the U.S. Savings Bonds Division, Treasury Department, Washington, D.C.

The United States Government does not pay for this advertising. The Treasury Department thanks, for their patriotic donation, the Advertising Council and

Product Engineering

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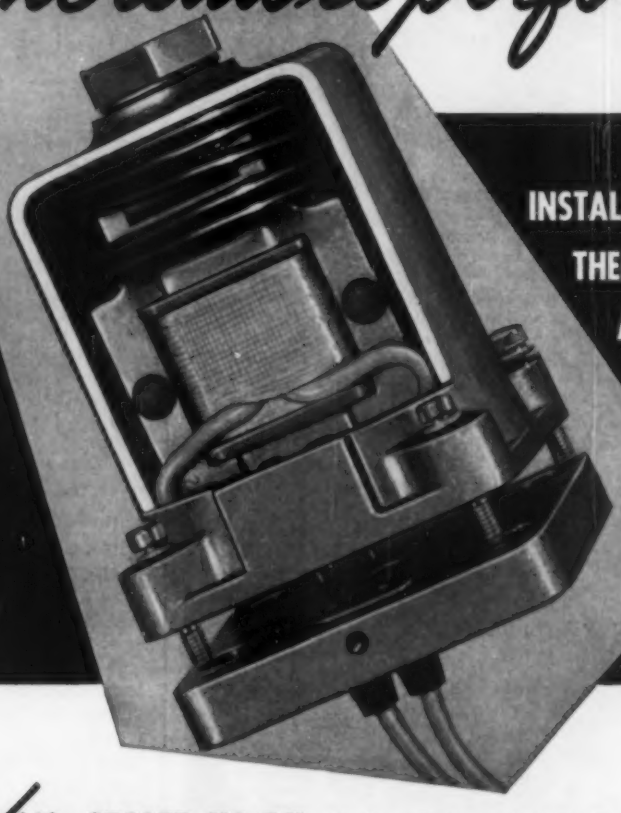
Decco OIL-IMMERSED SOLENOIDS *give incredible performance*



INSTALL THEM AND FORGET THEM. TESTS SHOW NO APPRECIABLE WEAR AFTER MILLIONS OF STROKES.

Here's why:

SEALED IN OIL. Each unit is sealed in its own, contamination proof, oil filled, die-cast housing. A convenient, plug-in base allows split-second replacement in case of change in power requirements. Heat dissipation and wear control reach a new level of efficiency in these units.

SHOCK MOUNTED. Only DECCO can give you service-proved, two direction shock-mounting—a valuable bonus in the service-life of your solenoids.

BETTER ENGINEERING. Minimum power loss. 30° to 50° cooler operation. Tremendously greater service-life.

DECCO Solenoids are made in a complete range of types, sizes and mountings. AC or DC. SPECIAL SOLENOIDS will be engineered on request.

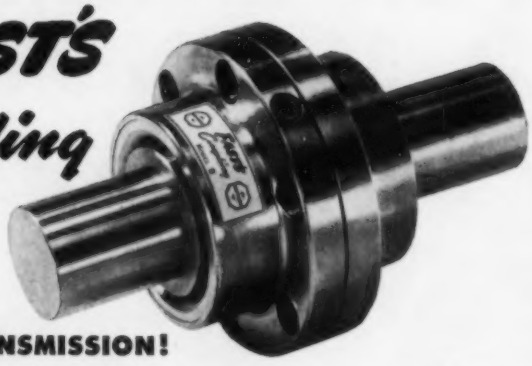
Decco SOLENOIDS THE HEART OF DEPENDABLE AUTOMATION EQUIPMENT

DETROIT COIL COMPANY

2435 HILTON ROAD, FERNDALE 20, MICHIGAN

The incomparable Model B

FAST'S Coupling



LOW-COST POWER TRANSMISSION!

Designed for light and medium drives—fans, blowers, pumps—a lighter, smaller and lower priced Fast's Coupling! The same famous features found in all Fast's Couplings . . . the same mechanical flexibility, the same positive lubricating principle, the same rugged construction and trouble-free performance . . . the same highly efficient power transmission which has made Fast's Couplings the leader for more than 30 years! Available for shaft sizes up to 2⅞" and sold with Koppers' free engineering service. For the low-cost solution to your shaft coupling problem, write: Koppers Company, Inc., *Fast's Coupling Dept.*, 7109 Scott Street, Baltimore 3, Md.

THE ORIGINAL FAST'S Couplings

KOPPERS

METAL PRODUCTS DIVISION • KOPPERS COMPANY, INC. • BALTIMORE 3, MD. This Koppers Division also supplies industry with American Hammered Industrial Piston and Sealing Rings, Industrial Gas Cleaning Apparatus, Aeromaster Fans, Gas Apparatus. Engineered Products Sold with Service.

NOW! new economies in NYLON GEARS means savings in gear costs up to 90%

Our many years of successful production of Nylon Gears can now make even greater economies for you. With the great variety in molds now possible, Nylon should not only be considered as an economy measure but the answer to many problems where compact design is necessary. Nylon Gears are quiet, durable, efficient and need less lubrication—they mate perfectly with metal gears.

Let our engineers with more than a decade in gear experience consider your gear problems DURING the design process—send blueprints or specs for prompt estimates.

Gears made only to your specifications. None carried in stock.

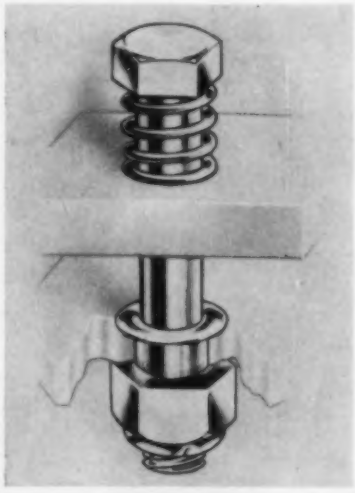
107

PROCESS GEAR CO., INC.

4601 W. Fullerton • Chicago 39, Illinois

wood, paper, fabric, metal, plaster or turf. Three interchangeable pins act as seating anchors, rewind handles and curvature guides. Laramie Chemical Corp., 290 Main St., Stamford, Conn.

For more information—Circle 30, inside back cover



Miniature self-locking clinch nuts . . .

feature a shank design that permits flush installation in stock as thin as 0.030-in. For applications with limited space allowances for fastening and assembly. Designed with a special nylon locking insert for temperatures to 350 F and an all-metal nut with an elliptical crown locking device for use to 550 F. Both require only two shank lengths for flush mounting installation. Thread sizes are 2-56, 4-40, 6-32, 10-24, 10-32, ¼-20 and ¼-28. Nuts are made of cadmium-plated steel. Elastic Stop Nut Corp. of America, Union, N. J.

For more information—Circle 31, inside back cover

High-output pressure transducer . . .

combines small size with accuracy of ±5% of full scale with hysteresis of 0.25%. Output varies from 25 to 100 millivolts full scale depending on the pressure range. Minimum output is 5 millivolts per volt of excitation; the maximum, 10 millivolts per volt of excitation. Total weight of the stainless steel unit is 7 g. Designed to mount flush with inner surface of the pressure chamber to measure fast pressure variations. Standard excitation is 6 v, ac or dc. Temperatures may vary from —100 to 300 F. Available in pressure ranges from 0 to 3 psi to 0 to 300 psi with an overload protection of two

(Continued on page 158)

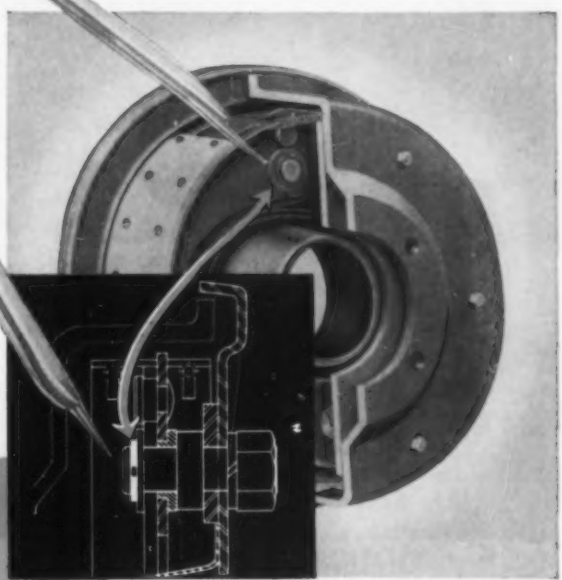
Opportunity for Designers...

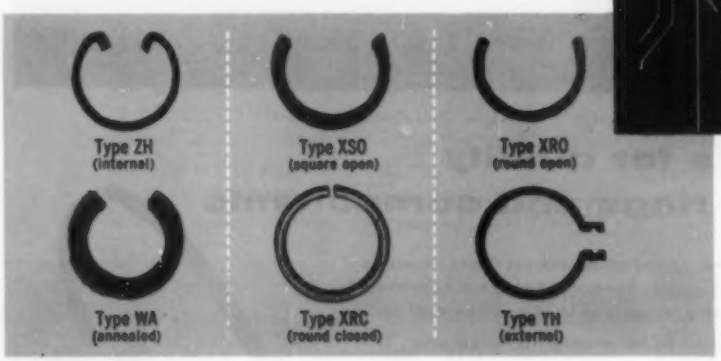
Cut your costs!
Improve your products!

NATIONAL
RETAINING RINGS

Here's how National Retaining Rings can Save Time and Money—

- **REDUCE WEIGHT**
- **SAVE MATERIALS**
- **SAVE SPACE**
- **SIMPLIFY ASSEMBLY**
- **REDUCE PRODUCTION OPERATIONS**





TYPICAL APPLICATION—

A 25% saving in assembly cost resulted when retaining rings were employed in this electric brake. Elimination of a nut, the threading of one end of shaft and reduction of 8" in the length of an anchor pin effected additional important cost reductions.

Consult a NATIONAL Engineer— He has the facts on thousands of successful applications and will be happy to discuss your specific design problems at your convenience. Just call or write, today!

THE NATIONAL LOCK WASHER COMPANY

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...Amweld® stands for quality flash butt-welded rings and components

Sixty thousand feet up and exceeding the speed of sound, jet flight imposes incredible demands upon engine components. Through constant research in close cooperation with the aircraft industry, American Welding has kept pace.

Today it supplies rings for every major U. S. jet engine manufacturer. New techniques have been developed to form and flash butt-weld metals like titanium and other hard-to-work stainless and heat-resistant alloys. This results in rings and other products of greatly improved quality... at reduced cost. These savings, amounting to millions of dollars yearly, are helping our nation get more for its defense dollar.

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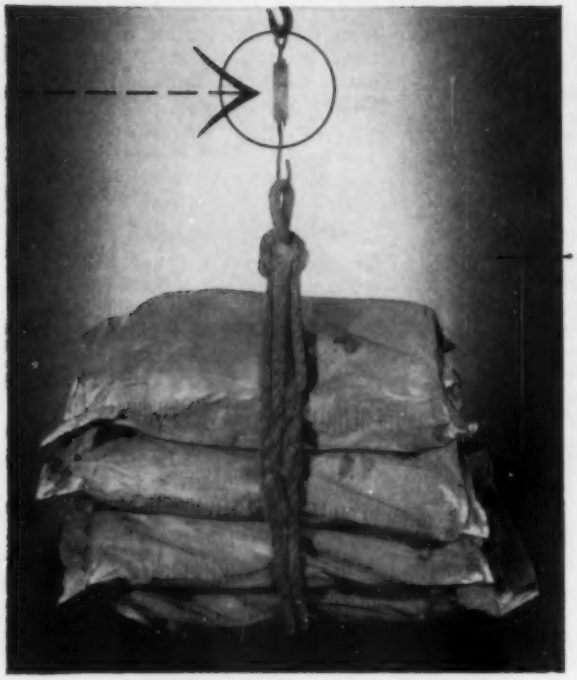
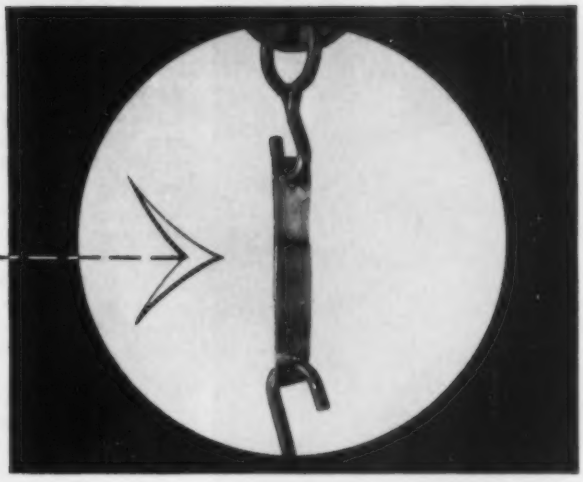
P&S SINCE 1884

DIGEST

•ADHESIVE

LATEST DEVELOPMENTS IN ADHESIVES FOR INDUSTRY





METAL-TO-METAL WITH HYBOND "56"

No cold flow under 200-pound dead load!

Said P&S technicians, "Let's check the 'ultimate' of HYBOND "56" " . . . and so they devised the severe test shown here. From a 1" x 1" metal-to-metal bond of HYBOND "56", four 50-pound bags were suspended in shear. After six weeks, no semblance of creeping or cold flow!

This test, one of many equally amazing, truly symbolizes the degree of performance inherent in HYBOND "56". Collateral advantages offer added prestige to its versatility — greater peel strength, higher heat resistance, unique sprayability.

Small wonder this fast-setting formula is specified for more and more counter and desk tops, porcelainized metal, honeycomb partitions, curtain walls, trailer bodies and a host of other critical applications.

Complete technical data on HYBOND "56" may be obtained by mailing the handy coupon. No obligation, of course.

P&S SINCE 1884

PIERCE & STEVENS CHEMICAL CORP.
Dept. P-2
710 Ohio Street, Buffalo 3, N.Y.

Please send complete technical data on HYBOND "56", also comprehensive P & S Product Catalog as illustrated at left.

Name _____

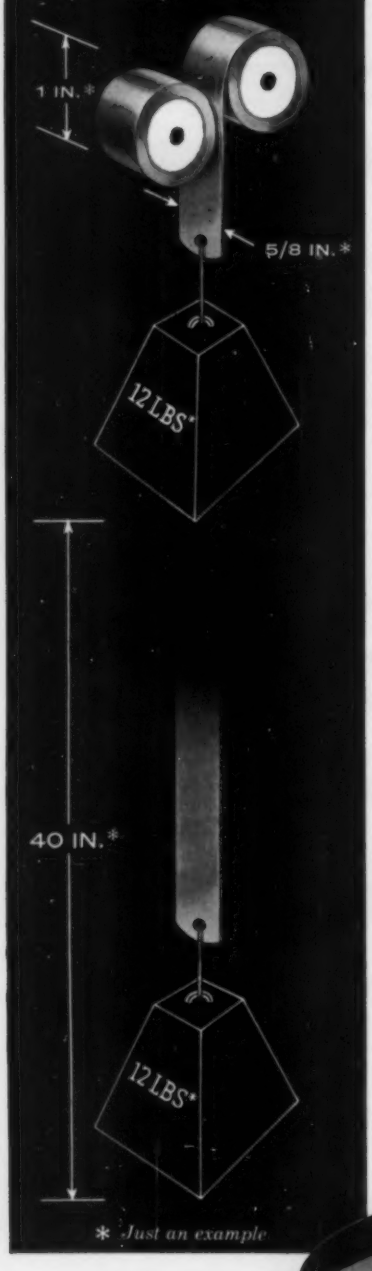
Title _____

Company _____

Address _____

City _____ State _____

BALANCE IT *with a*
NEG'ATOR® *constant-force spring*



NEG'ATOR is the name of a new kind of spring—the coiled-band spring that extends many times its original size without the increasing force common to conventional springs.

One of the natural uses of the NEG'ATOR Spring is counterbalancing without mass—vertically as illustrated, or horizontally. Using the NEG'ATOR Spring, the design engineer can eliminate dead weights or linkages and gain space, freedom of motion, reduced over-all weight, simplified assembly.

For example, each of the NEG'ATOR Extension Members used back-to-back in the illustration measures about 1 inch in diameter when coiled. They will counterbalance a 12 lb. weight over about 40 inches of travel. The only force required to move the weight is that required to overcome friction in the mechanism. There is no intercoil friction in the NEG'ATOR Spring.

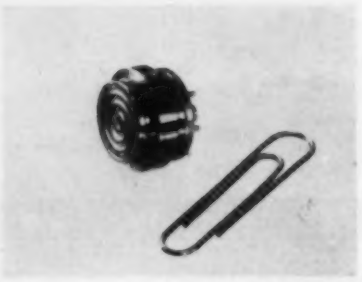
NEG'ATOR Springs in extension or motor form are versatile in counterbalancing functions—are now being used to balance light tank floats in sensitive liquid-level indicators and fire doors and other heavy equipment. Extensions range to over 20 feet.

Used as an extension spring, a motor, band, clamp, or clip—this revolutionary new *constant-force* component upsets all previous spring principles, opens a whole new field of mechanical design by doing what springs have never done before.

These and other functions of Hunter NEG'ATOR constant-force springs are described in Bulletin 310N, "The Story of the NEG'ATOR Spring." Send for a copy.

neg'ator
constant-force spring

HUNTER SPRING COMPANY
5 Spring Avenue, Lansdale, Pennsylvania
SPRINGS • STAMPINGS • TEST APPARATUS



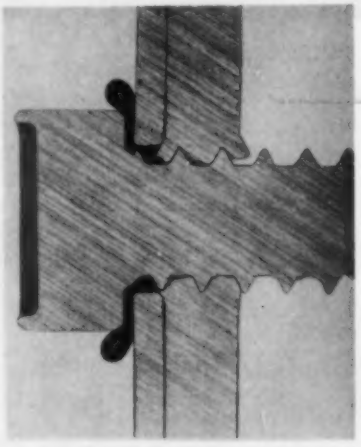
times the stated pressure range. Units come in gage, differential or absolute models. Dynamic Instrument Co., 28 Carleton St., Cambridge, Mass.

For more information—
Circle 32, inside back cover

Laminated transmission belt . . .

for speeds between 7 and 1700 fpm. Resilient plastic belt is bonded to a soft tanned chrome leather running surface. Because of its narrower width, user can employ narrower and/or smaller pulleys. Available in ¼ to ½ in. widths. Permits full utilization of motors at highest rpm. Belt is oil and moisture-resistant. Particularly suited for shockload drives, such as crushers, hammermills, compressors, pumps, or paper machines with flat or cone drives. Costa International Corp., 250 Park Ave., New York 17, N. Y.

For more information—
Circle 33, inside back cover



Waterproof, vibration-dampening fastener seal . . .

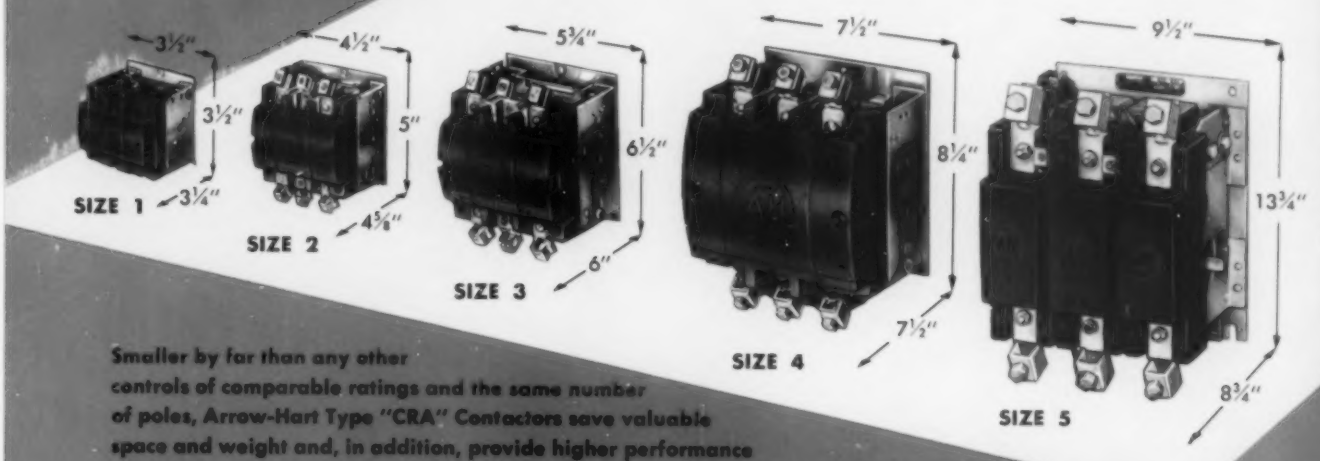
with a cushioning feature to protect porcelain and other highly finished appliance surfaces. It consists of a self-conforming nylon washer preassembled to a standard self-tapping screw. The washer compresses against head and threads of the fastener as the screw is turned in

(Continued on page 161)

ARROW AH HART

POWER CONTACTORS

give you FINER PERFORMANCE in HALF the size



Smaller by far than any other controls of comparable ratings and the same number of poles, Arrow-Hart Type "CRA" Contactors save valuable space and weight and, in addition, provide higher performance standards with greater dependability, longer life and faster, easier installation and maintenance. Available in a complete line — from Size 0 to Size 5 — they provide the right control for all your requirements.

CONSTRUCTION FEATURES - -

Straight-Thru Wiring is quickly, easily accessible from the *front*. Double break contacts, of silver cadmium oxide for weld resistance on high inrush currents, are accessible from the front for fast, simple inspection or replacement. Molded AC operating coils resist moisture and dirt . . . normally last the life of the relay itself. Resinox base and hood provide maximum arc and tracking resistance.

OPERATING FEATURES - -

Magnets are designed for high-efficiency, low wattage operation. Exclusive mechanical design – available only on Arrow-Hart Controls – has proved its ability to operate dependably under the most adverse conditions.

EXTRAS AVAILABLE - -

If required, Arrow-Hart Type "CRA" Contactors can be supplied with: NEMA Type I, IV, VII, IX & XII Enclosures. Sizes 0, 1 & 2 can be supplied with coils & magnets for up to 250 volts DC.

"CRA" SELECTOR GUIDE

"CRA" UNIT	POLES	AUXILIARY HOLDING SWITCH	CONTINUOUS RATINGS IN AMPERES	EXTRA AUXILIARY SWITCHES
Size 0	2-5, N.O.	Optional	18	Yes
Size 1	2-5, N.O.	Optional	27	Yes
Size 2	2-5, N.O.	Yes	45	Yes
Size 3	2-5, N.O.	Yes	90	Yes
Size 4	2-5, N.O.	Yes	135	Yes
Size 5	3-5, N.O.	Yes	270	Yes

RESISTIVE HEATING LOADS (KW)

"CRA" UNIT		A-C VOLTAGE			
SIZE	PHASE	115	230	440	550
1	1	2.5	5	10	12.5
	3	4	8	17	21
2	1	5	10	20	25
	3	8.5	17	34	43
3	1	10	20	40	50
	3	17	34	68	86
4	1	15	30	60	75
	3	26	52	105	130
5	1	30	60	120	150
	3	52	105	210	260

HORSEPOWER RATINGS

"CRA" UNIT		A-C VOLTAGE		
SIZE	PHASE	110	220	440/550
0	1	1	2	3
	3	2	3	5
1	1	2	3	5
	3	3	7½	10
2	1	3	7½	10
	3	7½	15	25
3	1	7½	15	25
	3	15	30	50
4	3	25	50	100
5	3		100	200

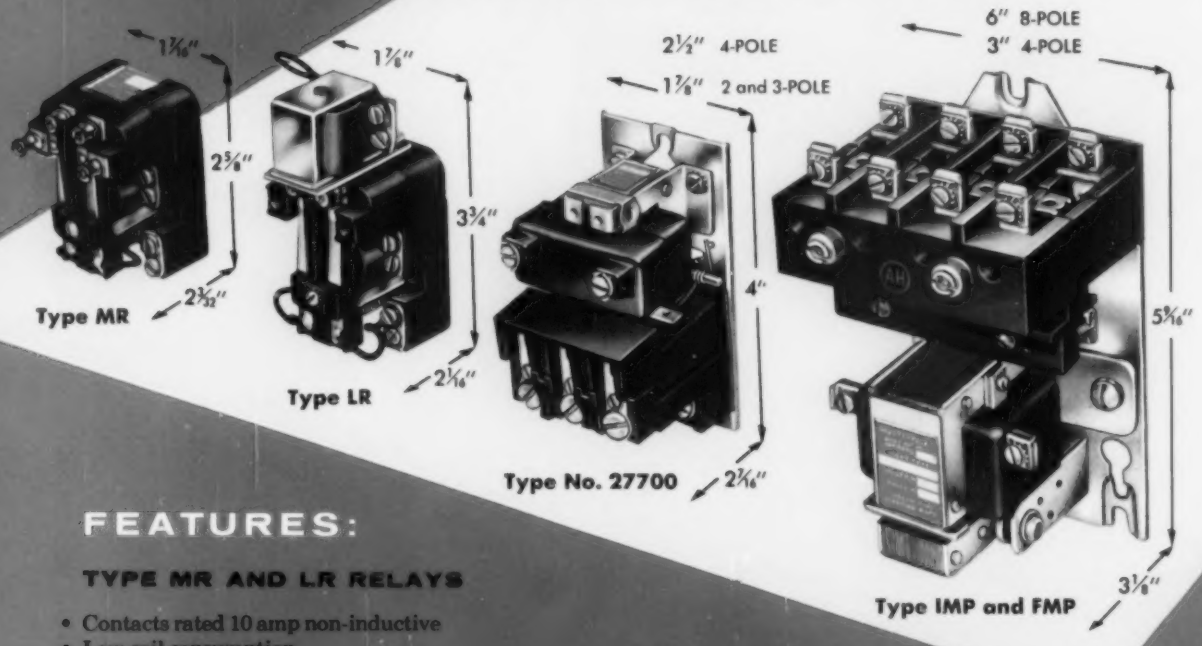
PLEASE TURN THE PAGE FOR ADDITIONAL INFORMATION . . .

ARROW AH HART

RELAYS

have EVERY feature you want --

LONG LIFE, ADVANCED DESIGN, VERSATILITY



FEATURES:

TYPE MR AND LR RELAYS

- Contacts rated 10 amp non-inductive
- Low coil consumption
- Contacts have wipe action
- A, B and C type contacts available
- Available 1 to 4 poles
- Coils available in all common A.C. or D.C. voltages
- Exceptionally long life
- Type LR -- Latch-in or Latch-out or both

HEAVY DUTY RELAY, Type 27700

- Ideal for the new, heavy duty commercial appliances
- 20 amps per pole at 300V A.C.
- 120 amps interrupting capacity
- Coil inrush 12 watts (Approx.)
- Coil sealed 2.5 watts (Approx.)
- Available 2, 3 or 4 poles A.C.

TYPE IMP AND FMP

- Size 00 and 0 for operation to 600V A.C. or 250V D.C.
- Available with 2, 3, 4, 6 or 8 poles
- Instant interchangeability of contacts -- no disassembly or reassembly of contacts
- Plug-in receptacle available for all sizes
- Latch attachment can be added by user
- Latch is convertible to latch-in or out or both
- Same coil and magnet regardless of number of poles

USE THIS COUPON TO SEND FOR COMPLETE INFORMATION ON ARROW-HART RELAYS AND POWER CONNECTORS

AH

THE ARROW-HART & HEGEMAN ELECTRIC COMPANY

103 Hawthorn Street, Hartford 6, Connecticut • Motor Control Division

Please send me complete engineering data on:

☐ Type "MR" and "LR" Relays ☐ Type "IMP" and "FMP" Relays
☐ 20-Ampere Relays ☐ Type "CRA" Contactors
☐ I am also interested in other industrial motor controls.

name _____
position _____
company _____
co. address _____
city _____ zone ____ state _____

PE

ARROW AH HART

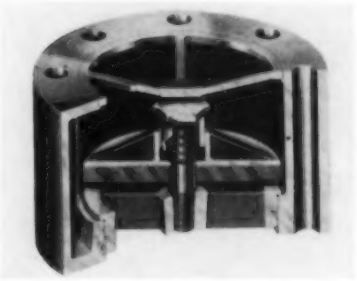
Quality since 1890

WIRING DEVICES • MOTOR CONTROLS • ENCLOSED SWITCHES • APPLIANCE SWITCHES

Branch Offices and Sales Engineers Throughout the United States.

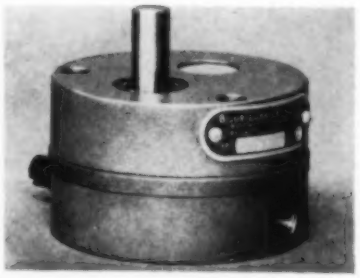
and seals against moisture. Washer is translucent, eliminating the problem of color matching Electrolytic deterioration resulting from contact of dissimilar metals is retarded by the washer. Can be furnished with any head style. Parker-Kalon, div. General American Transportation Corp., Clifton, N. J.

For more information—
Circle 34, inside back cover



Spring-loaded check valves . . .
improves the performance of fluid systems wherever line surges and drop-back present a problem. The internal disk closes immediately as flow ceases and does not depend upon reverse flow for shut-off. Metal-to-metal or plastic-to-metal seating permit a leak-proof seal. Valve operates in any position. Standard sizes are from 2 to 18 in. Pressures range to 2500 psi. Body and trim are supplied to meet specific requirements. Combination Pump Valve Co., 850 Preston St., Philadelphia 4, Penn.

For more information—
Circle 35, inside back cover



Sealed gear pump for lubricating . . .
for mounting on any machine requiring fluid circulation for lubrication or other purposes. The unidirectional pump has a lip-style seal, located on the drive shaft, that will withstand back pressures to 20 psi. Pressure to the inlet of the pump is vented by means of a pressure relief system. Built-in relief valve prevents loading the seal above rated limitations. Discharge is 50 cu cm/min at 100 rpm.

(Continued on page 164)

Special WIRE CLOTH PARTS

save money

save time

no production problems

no quality problems

Newark is the place to come for your fabricated wire cloth parts. We can save you time and money. We weave our own wire cloth so you have no quality control problem. We take care of production scheduling . . . you have no idle manpower or idle machine time worries. We will give you a better part at a lower cost.

For more data on this phase of NEWARK Service, send for our Wire Cloth Parts Catalog. If you have an individual problem and would like to have us recommend the best way to insert the wire cloth piece send us tentative drawings and specifications. If you are ready to order, we'll be glad to quote.

NEWARK for ACCURACY

Newark Wire Cloth COMPANY

351 Verona Avenue, Newark 4, New Jersey

Taylor's New

Copper-Clad Laminate

Cu-246

for volume users of printed circuits

HERE'S WHY TAYLOR Cu-246 COPPER-CLAD LAMINATE CAN GIVE YOU *BETTER* PRINTED CIRCUITS

- good mechanical and electrical stability over wide humidity range
- ready punchability . . . can be cold punched and cold sheared up to 1/16" thickness
- resists all commonly used solvents
- good insulation resistance . . . has excellent surface resistivity after etching

Now available for volume production of printed circuits, the new Taylor Grade **Cu-246** copper-clad laminate is the result of two years of research and field testing.

The base material is a translucent paper base grade with a special phenolic type resin formulated to be well balanced in electrical and mechanical properties to meet the varied solvent resistance and process requirements encountered in printed wiring production.

High purity rolled copper is again used in this new printed circuit material assuring you of the consistently dependable performance found in the other printed circuit laminates being produced by Taylor. Rolled copper has no lead inclusions and is free of pits, pinholes and other imperfections.

The rolled copper surface is adaptable for silk screening, offset printing or photoengraving processing . . . also for semi-precious and precious metal plating, with a minimum of preparation. **Cu-246** is available in all standard sheet sizes . . . special sizes supplied on request . . . in thicknesses from .020" to .250" . . . with copper on one or both sides.

You'll get the same dependable performance from Taylor **Cu-246** as you have from other laminates in the list of Taylor materials. For more detailed information on Taylor **Cu-246** . . . for a discussion on how this new copper-clad laminate can help you make better printed circuits at lower cost . . . contact your nearest Taylor sales office.

TAYLOR FIBRE CO., PLANTS IN NORRISTOWN, PA. AND LA VERNE, CALIFORNIA

INTEGRATED MANUFACTURER & FABRICATOR OF
Phenolic—Melamine—Silicone—Epoxy—Copper-Clad and
Combination Laminates • Vulcanized Fibre

TAYLOR
Laminated Plastics
Vulcanized Fibre

GOLD-N-RING ... a new name and a new conception of CONTROL SWITCH design

HEAVY-DUTY

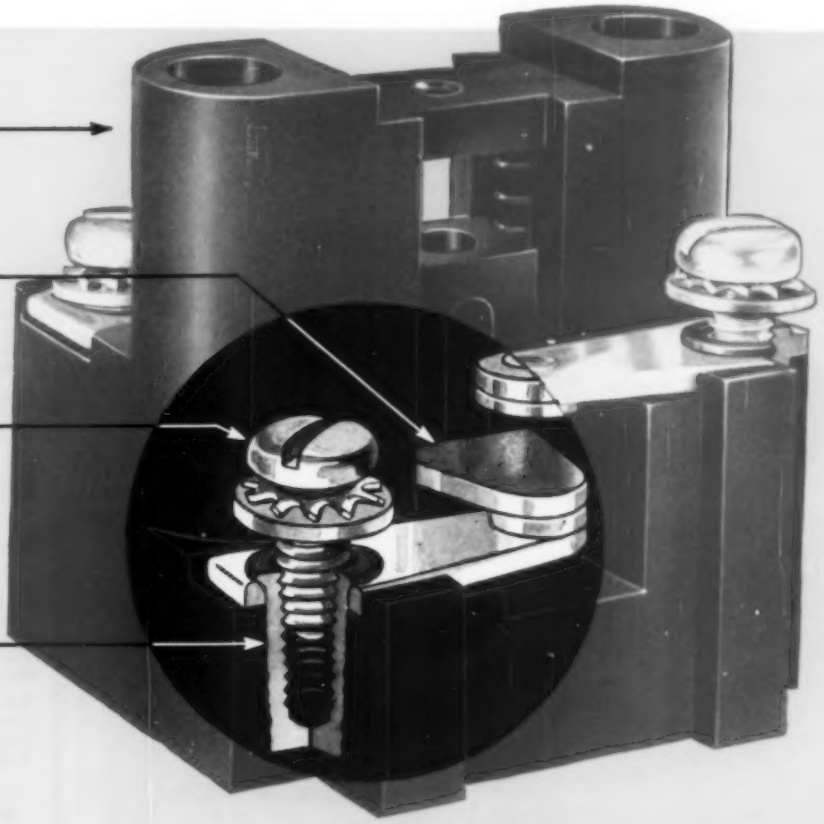
OIL-TIGHT—WATER-TIGHT—DUST-TIGHT

made by machine tool builders to machine tool specifications

A new name—GOLD-N-RING Sealtight Control Switch! A new conception—a control switch *designed and built BY a manufacturer of machine tools—FOR machine tool builders!*

A product of the same machine tool background responsible for Namco Solenoids and Snap-Lock Limit Switches, it gives designers a *package of greater electrical efficiency*—available from a single source, with a single source responsibility.

Shown here are only a few of many reasons why the GOLD-N-RING Control Switch makes it possible to match machine tool mechanical ruggedness with equally durable electrical efficiency.



1. **MAIN BLOCK** is unit-molded to assure alignment and simplify assembly.

2. **HEAVY-DUTY SILVER-ALLOY CONTACT POINTS** for maximum electrical capacity and long life.

3. **HEAVY-DUTY TERMINAL SCREWS**, with 3/8" thread contact, prevent stripping during installation; permanently secure wires for continuous trouble-free service.

4. **BRASS INSERTS MOLDED IN THE BLOCK** permanently hold stationary contacts. They also provide more thread support for the No. 8-32 terminal screws that are equipped with captive flat and lock type washers.

For complete details, send for Bulletin ECS-56. Better yet, ask for a representative to bring a switch for your examination.

ELECTRICAL MANUFACTURING DIVISION

National Acme

THE NATIONAL ACME COMPANY • 170 EAST 131ST STREET • CLEVELAND 8, OHIO

ELECTRIC
Wheels · Axles · Spindles

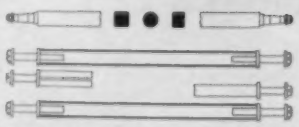
DIVIDED WHEELS
Generally used as dolly, tail or caster wheels

FOR TRUCK TIRES
Full drop center rim to utilize used truck tires on larger implements

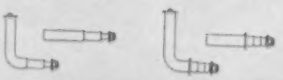
PLANTER WHEELS
Steel rim or for use with planter rubber tires

SIX BOLT SERIES
Light and heavy —widest range of implement use

Four bolt series for light implements



Hub and bearing combinations available. Stub spindles and full length axles.

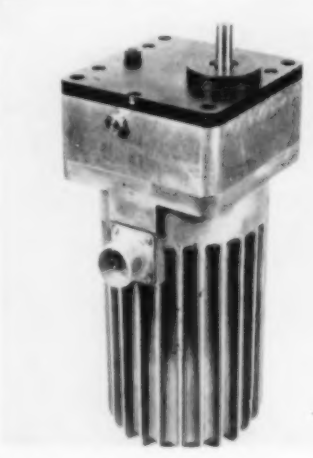


Our Engineers Invite Your Inquiries

ELECTRIC WHEEL COMPANY
DIVISION OF THE FIRESTONE TIRE & RUBBER COMPANY
2805 SPRUCE • QUINCY, ILLINOIS

Recommended speed range is 20 to 1000 rpm. Dimensions are 2½ in. dia x 1½ in. high. Mounting holes permit installation either on a bracket or in any position desired on the machine surface. Bijur Lubricating Corp., 151 W. Passaic St., Rochelle Park, N. J.

For more information—
Circle 36, inside back cover



Brake-equipped gearhead motor . . .

will stop within 0.2 sec and within 25° of output shaft of gear box. The two-speed motor, two and six-pole, is designed for 220 v ac, 60 cps, three-phase, rated as 1/10 hp output at 250 rpm and 84 rpm, intermittent duty at high speed, continuous duty at low speed. Totally enclosed. Filled with GE Versolube F-50 silicone fluid for cooling. Operates in ambient temperatures of —65 C to 200 C, 100% humidity. Western Gear Corp., P.O. Box 182, Lynwood, Calif.

For more information—
Circle 37, inside back cover

Long-print viewer . . .

holds blueprints, drawings, or photos, to 40 ft or more in length in an area of about 40x48 in. on wall, table or desk. Available

(Continued on page 167)

There's a *Bird*
JEWEL BEARING
to fit Your Need!

Bird can supply you with sapphire and borrosilicate glass precision jewel bearings in a wide range of standard types, sizes, and complete assemblies — or, custom-built to your specifications. Special mounting techniques provide exact tolerance jewel assemblies, mounted or set in bushings or screws, ready for assembling into your product without further inspection. Jewels mounted with resilient silicone rubber or spring cushions provide additional protection to shock and vibration.

Because of the exact tolerances, maintained through the most rigid quality-control methods, Bird jewels are used by the foremost manufacturers of electrical, aircraft, and timing instruments — and recorders.

Typical products include:

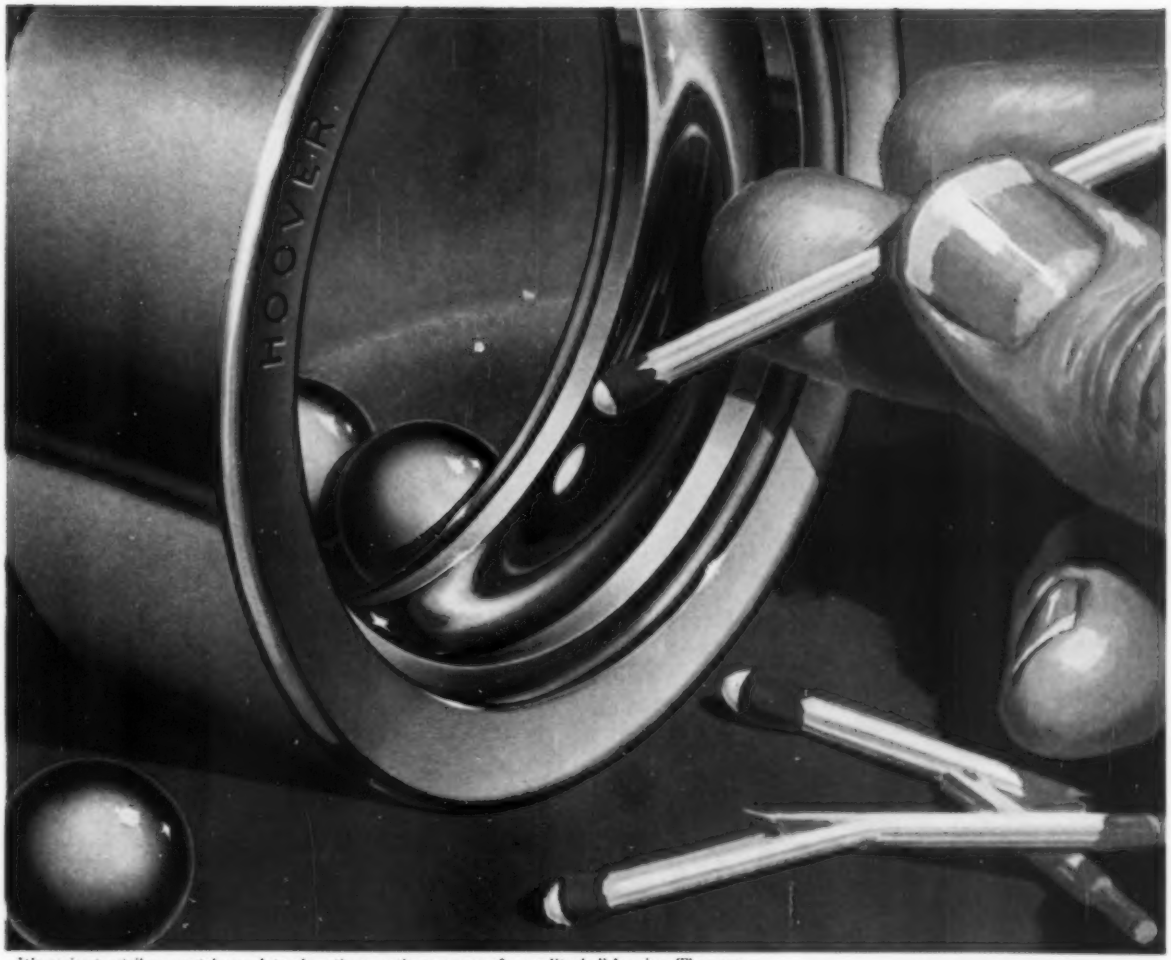
Aircraft Instruments
Weather Recorders
Ammeters
Voltmeters
Wattmeters
Compasses
Dial Gages
Timers
Test & Recording Instruments
Marine Instruments

**Illustrated — Concentricity check of mounted ring jewels — one of the inspection processes in Bird's quality control program.*

Our engineering staff is at your service for all small bearing problems. A request on your letterhead for Bulletin 100-6 will receive our prompt attention.

Richard H. Bird & CO., INC.
1 SPRUCE ST., WALTHAM 54, MASS.

SAPPHIRE & GLASS JEWELS
PRECISION GLASS GRINDING
JEWEL MOUNTING & ASSEMBLY



It's easier to strike a match on plate glass than on the raceway of a quality ball bearing. The raceway's smoothness makes it virtually impossible. Even so, not all bearing raceways are equally smooth.

Hoover Honed Raceways are super smooth . . . superbly finished

Bearing life—load capacity—quietness. These and other factors in ball bearing performance depend largely on the smoothness and finish of the bearing's raceway.

And that's where *Hoover Honed* Raceways pay off . . . in extra smoothness and finish. All makes of bearing raceways are ground. But Hoover Raceways are also *fully honed*. Hoover Honing, a patented process developed by Hoover, is the last word in precision finishing for raceways.

Coupled with *Hoover Honed* Raceways are matched sets of Hoover *Micro-Velvet* Lapped Balls, made to unusually high standards of smoothness and roundness. Precision throughout the working surfaces achieves superior ball bearing quality . . . assures long life and unexcelled performance.

Investigate Hoover's line of ball bearings in the light, medium and heavy series, available in a variety of types. Hoover engineers are ready to assist manufacturers with engineering and design information. Write Hoover about your problem.

hoover

BALL AND BEARING COMPANY, ANN ARBOR, MICHIGAN

Hoover Honed and *Micro-Velvet* are Hoover Trademarks.

HOOVER HINTS:

Common Causes Of Bearing Failure

What makes an anti-friction bearing stop doing its assigned job? Improper lubrication, foreign bodies, soft balls or raceways, poor race concentricity, high operating temperatures and incorrect bearing selection—all are possible causes for premature bearing failure.

Common causes of bearing failure is but one of the many problems confronting users of anti-friction bearings—this problem as well as others pertaining to bearings are given concise coverage in the Hoover Handi-Book of Anti-Friction Bearings. Write for your copy today . . . it's written to help you select the right bearing for any application.

Hoover Ball and Bearing Company,
Ann Arbor, Michigan.

Mail my copy of "Hoover Handi-Book of Anti-Friction Bearings."

Name_____

Title_____

Company_____

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City_____ State_____

11

CLARK Type "CY" Starters, sizes 0 and 1, now have higher NEMA horsepower ratings

As shown in the table below, NEMA maximum horsepower ratings for size 0 and 1 AC magnetic across-the-line starters have been increased. Clark Type "CY" starters now available to meet these new standards will, in many cases, permit you to meet your requirements with smaller sizes. You can at once take advantage of the money and space savings made possible by this re-rating.

CHANGES IN NEMA STANDARDS FOR MAXIMUM HORSEPOWER RATINGS OF AC MAGNETIC STARTERS AND CONTACTORS

SIZE AND VOLTAGE RATINGS	MAXIMUM HP RATINGS	
THREE PHASE	**OLD**	**NEW**
Size 0 110V	1½	1½
Size 0 208/220V	2	**3**
Size 0 440/600V	3	**5**
Size 1 110V	3	3
Size 1 208/220V	5	**7½**
Size 1 440/600V	7½	**10**
SINGLE PHASE		
Size 0 110V	1	1
Size 0 208/220V	1½	**2**
Size 0 440/600V	2	**3**
Size 1 110V	1½	**2**
Size 1 208/220V	3	3
Size 1 440/600V	5	5

NOTE: HP ratings for plugging and jogging duty have not been revised.

IN ADDITION TO COST AND SPACE SAVING BENEFITS OF THE NEW NEMA RATINGS, CLARK Type "CY" STARTERS OFFER MANY OTHER ADVANTAGES:

Greater Dependability and longer life

- Heavy-duty mill-type construction.
- Large silver-to-silver twin-break contacts.
- Vertical lift, free-floating magnet uses no springs; pull characteristic assures positive contact closing and keeps magnet slam to a minimum.

Easier Maintenance

- Contacts and contact springs quickly and easily inspected—without tools.
- All parts readily accessible and replaceable from front without removal from panel or enclosure—screwdriver and wrench only tools needed.
- Magnet coils easily replaced.

Simplified Installation

- Generous wiring space.
- All terminals face the front.
- Pressure-type terminals line and load.

...and many others

These increased horsepower ratings for AC controls will be adopted for all forms of Clark across-the-line starting equipment.

Revised Clark Catalog sheets and price lists covering the new NEMA ratings are available on request.

The **CLARK CONTROLLER** *Company*

Everything Under Control **1146 East 152nd Street • • Cleveland 10, Ohio**

IN CANADA: CANADIAN CONTROLLERS, LIMITED • MAIN OFFICES AND PLANT, TORONTO

in wall (with brackets) or desk (with clamps) models. Prints are rolled flat on two vertical rolls and moved into view by turning either of two controls, located at the base. Interchangeable rolls for storing and preservation are available. Viewer is $80 for the wall model; $55 for the table model. Aqua Sportsman, Inc., 2518 Leslie Ave., Cincinnati 12, Ohio.

For more information—
Circle 38, inside back cover

Tracing paper and cloth . . .

with nonreproducible cross-section guide lines are said to speed hand lettering, ruling, measuring and scaling on original drawings. Prints show only drawn lines. Available on transparent 100% rag content tracing paper, in sheets, pads and rolls in standard widths, lengths and a variety of cross-sections, or water-repellent tracing cloth, in roll form. Charles Bruning Co., Inc., 4700 W. Montrose Ave., Chicago 41, Ill.

For more information—
Circle 39, inside back cover

Portable power supply . . .

provides continuously variable, regulated output, with a high-voltage vernier adjustment. A-c input is 105 to 125 v, 50-60 cps. D-c output is 12-300 v with zero to 100 ma or zero to 200 ma, depending on the model. A-c output is 6.3 v, at 3 or 6 amp center tapped. Regulation is 0.1% for line variations from 105 to 125 v ac; 0.1% for no-load to full-load. Dimensions are 8⅜ x 6½ x 16⅞ in. deep. Nutron Mfg. Co., 67 Monroe Ave., Staten Island 1, N. Y.

For more information—
Circle 40, inside back cover

Disposable molds permit three-dimensional . . .

true duplication of almost any part or model in epoxy or polyester resin from any solid model, sample, drawing or sketch. Can be reproduced with the exact finish of the sample. Electrical coil and electronic assemblies can be embedded in a plastic case with external detail, nameplates or embossing. Suitable for short runs, design studies and market survey samples. Parts can be finished in any color, clear or with compatible filler, and in many cases with undercuts and skew surfaces not possible by normal molding processes. Shrinkage varies from 0.002 to 0.015 in. per in., depending on the resin, filler, shape and curing cycle. DuVal Industries, Camel Hollow Rd., Huntington, N. Y.

For more information—
Circle 41, inside back cover

. . . the two-way answer to fastening problems

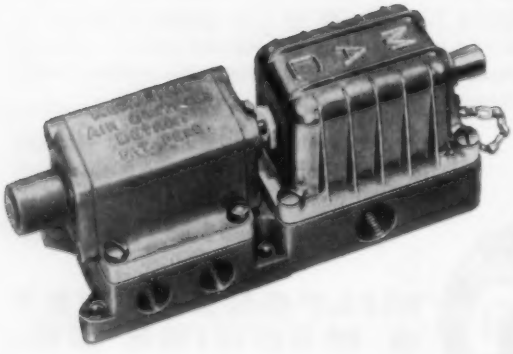
Here's a combination that slashes production costs and gets rid of fastening problems in a hurry—Milford Rivets made to high-quality standards to assure a better finished product for you . . . Milford automatic rivet-setting machines that can be quickly adapted to your particular fastening needs.

To improve product appearance and strength
. . . to take full advantage of automatic assembly
. . . to cut delivery time and production costs
—get in touch with Milford first!

THE MILFORD RIVET

MILFORD RIVET & MACHINE CO.
MILFORD, CONNECTICUT • HATBORO, PENNSYLVANIA
ELYRIA, OHIO • AURORA, ILLINOIS • NORWALK, CALIF.

Product of careful evolution



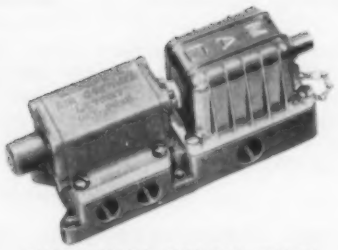
Take the pearl! It develops, layer by layer, until it attains rare beauty and value.

MAC air valves, too, are products of evolution. Step by step they have been developed with care and imagination. With each model, with each exhaustive test, improvement has been added to improvement—until now MAC valves are industry standards for performance and dependability.

Take the new MAC J.I.C. model, for example. It is the first valve that not only meets *but* exceeds all J.I.C. requirements—the only valve with completely independent body and solenoid and other important refinements. It's an example of what you can expect in *all* MAC valves, now and in the future. Get the facts. Call a MAC representative, listed at the side, or send for free literature.

MECHANICAL AIR CONTROLS, INC.
10030 Capital, Oak Park, Detroit 37, Michigan

MAC



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MIAMI SPRINGS—Aero Hardware & Supply Co., 4301 Northwest 36th St., TUxedo 8-2414

ILLINOIS
CHICAGO 43—Mike C. Modrich Co., 10918 South Western Ave., HIlltop 5-3640

INDIANA
EVANSVILLE—Neff Engineering Co., 2509 Washington Ave., GReenleaf 7-4141
FORT WAYNE 3—Neff Engineering Co., P.O. Box 2001, Station A, 2339 Crescent Ave., EAstbrook 7391
INDIANAPOLIS 20—Neff Engineering Co., P.O. Box 7361, 42nd St. Station, CLifford 5-5418
SOUTH BEND 15—Neff Engineering Co., 103 South Varsity Dr., CEntral 2-3800

MASSACHUSETTS (and New England)
BOSTON 34—Electrical Apparatus Co., Inc., 1200 Soldiers Field Rd., STadium 2-7440

MICHIGAN
BAY CITY—Fred Kober, 506 Chilson St., TWinbrook 2-2629
FLINT 2—Kober Sales Engineering Co., 1115 Root St., CEdar 2-7165
WESTERN MICHIGAN—Everett Adams, 17212 Sharon Road, Chesaning, Michigan, CHesaning 383-J-1

MINNESOTA
MINNEAPOLIS 4—Air Engineering & Supply Co., 2445 Nicollet Ave., FEderal 9-5579
MINNEAPOLIS 8—Air and Hydraulic Equipment Co., 15 E. 38th St., TAylor 3-6118
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DAYTON—The R. W. Nichols Co., 407 Realty Bldg., MIchigan 4724
OLMSTED FALLS—The R. W. Nichols Co., P. O. Box 6, ADams 5-3366
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PHILADELPHIA 41—Automation Aides, 4817 Old York Rd., MIchigan 4-0807

TEXAS
DALLAS 35—Womack Machine Supply Co., 2010 Shea Rd., FLeetwood 7-3871

WASHINGTON
SEATTLE—The Rucker Co., 1000 4th Ave., South, MAin 2783

WISCONSIN
MILWAUKEE 17—Neff Engineering Co., 5856 N. Pt. Washington Rd., EDgewood 2-1579

MECHANICAL AIR CONTROLS, INC.
DETROIT 37, MICHIGAN
MAC

CATALOGS and BULLETINS

To obtain copies of literature described below, circle corresponding number on postcard inside back cover.

MALLEABLE IRON CASTINGS—Brochure, 8 pp. Value analysis is applied to standard and pearlitic castings, designed for use by cost-reduction and value-analysis committees and purchasing departments. With specification tables. Malleable Founders' Society, 1800 Union Commerce Bldg., Cleveland 14

Circle 42, inside back cover

HEAD CAP SCREW DATA—Technical Guide, 8 pp. Torque-tension data on tightening torque required to produce a desired screw tension. Design considerations are emphasized and torque-tension terms are explained. Also, extensive data on physical characteristics, specifications, dimensions, thread lengths of standard stocked sizes. Mac-it Screw Div., Strong, Carlisle, and Hammond, 1392 W. Third St., Cleveland 13

Circle 43, inside back cover

17-4 PH AND 17-7 PH STAINLESS STEELS—Bulletin, 4 pp. Describes properties, corrosion resistance, high strength, workability and ability to harden at low heat-treating temperatures. Lists typical applications. Armco Steel Corp., 2557 Curtis St., Middletown, Ohio.

Circle 44, inside back cover

SELF-LOCKING HEX HEAD CAP SCREWS—Bulletin, 4 pp. Describes and illustrates how screws are made. Tables show diameter and location of pellets for stock screws in sizes ¼ through 1 in. dia, fine and coarse threads. Recommended installation practices are illustrated. Cleveland Cap Screw Co., Box 545, Cleveland 28

Circle 45, inside back cover

SEALING COMPOUNDS—Broadside, 4 pp. How to select the right compounds is the subject matter. Includes information on general characteristics, specifications, solvent and diluent data and extrusion volume. Presstite-Keystone Engineering Products Co., 39 and Chouteau Ave., St. Louis 10

Circle 46, inside back cover

TUBING FOR CYLINDRICAL PARTS—Bulletin R7A, 4 pp. Performance and application data, with cutaway drawings. Tube Reducing Corp., Wallington, N. J.

Circle 47, inside back cover

BRONZE AND IRON BODY VALVES—Catalog 57, 136 pp. Illustrated with dimensional diagrams and cutaway views and has technical data for the initial design of piping layouts. Includes table of equivalent resistance of valves, fittings and bends; charts for the rational solution of pressure drop for liquids, gases and steam. Fairbanks Co., 393 Lafayette St., New York 3, N. Y.

Circle 48, inside back cover

PLASTIC SHEETS, RODS, TUBES—Catalog and price list, 76 pp. Lists stock of Teflon, Nylon, Kel-f, phenolic, Plexiglas, Evr-kleer, polystyrene, CR-39, Rexolite, polyethylene, acetate and Vinylite. Has thumb index. Allied Plastics Supply Corp., 75 Cliff St., New York 38, N. Y.

Circle 49, inside back cover

COLD FINISHED STEEL BARS—Wall chart. Shows all AISI grades of bars. Lists 241 grades. Machinability ratings are given. Chart covers eight AISI grades of screw machine steels, 25 AISI grades of resulphurized carbon steels, 64 AISI grades of open hearth steels, and 140 grades of alloy steels. There is also a table of weights, which gives weights in lb per ft for round, square and hexagonal steel bars of thicknesses or diameters of $\frac{1}{32}$ in. to 6 in. La Salle Steel Co., P.O. Box 6800-A, Chicago 80

Circle 50, inside back cover

HIGH-TEMPERATURE ALLOY—Booklet, 24 pp. Information on stress-rupture strength, short-time tensile data and fatigue and creep data is included on this chromium-nickel-cobalt steel. Methods for welding, forming and machining are also included. Haynes Stellite Co., Div. of Union Carbide Corp., 30-20 Thomson Ave., Long Island City 1, N. Y.

Circle 51, inside back cover

ENVIRONMENTAL TESTING — Brochure, 4 pp. Facilities for testing to military, ASTM, and industrial specifications are shown and described. Associated Testing Laboratories, Inc., 414 Clinton Rd., Caldwell, N. J.

Circle 52, inside back cover

RUBBER PARTS—Catalog, 12 pp. Describes and illustrates facilities for manu-

(Continued on page 170)

150,000,000 standard fastenings in Brass, Bronze, Stainless, Aluminum, Copper, Nickel and Monel!

A call to your Harper Distributor and the fastening you want is on its way! Easy as that because he stocks thousands and thousands of standard fastenings for your convenience. Why shop? Why wait? Call your Harper Distributor for specialized attention and immediate delivery!

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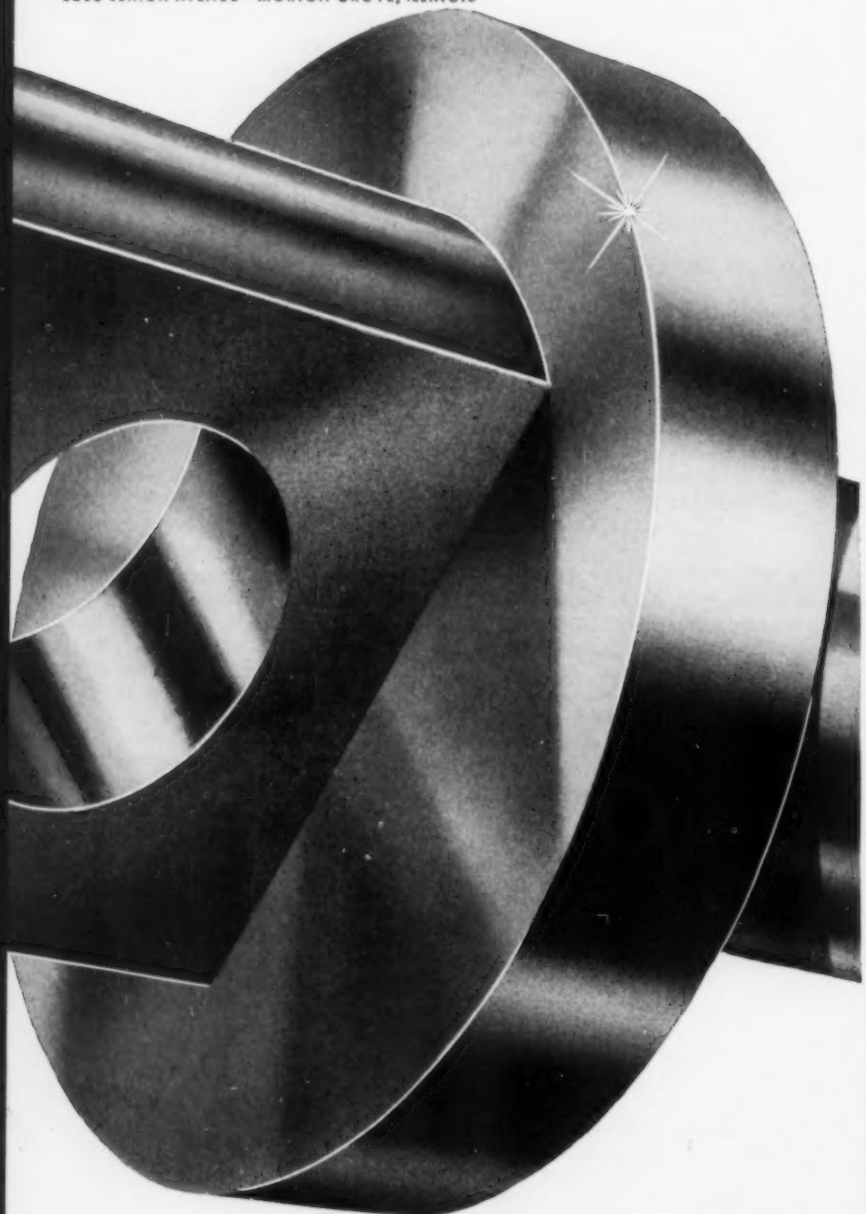
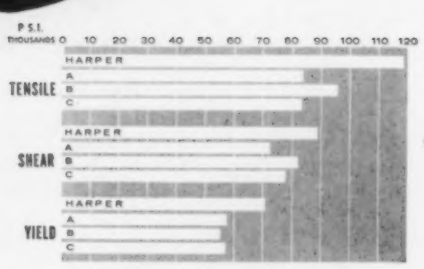
THE H. M. HARPER COMPANY
8203 LEHIGH AVENUE • MORTON GROVE, ILLINOIS



Laboratory tests prove greater strength of Harper stainless steel machine bolts

Independent laboratory tests* on stainless steel machine bolts produced by The H. M. Harper Company and three other leading producers of fastenings, prove Harper superiority in Yield, Tensile, and Shear Strength. Chart shows the actual results of these tests . . . irrefutable proof of Harper superiority! For complete details request Form No. 126.
*By R. W. Hunt Laboratories



facturing parts to customer order. Included are identification tables adopted by the SAE and ASTM, descriptions of natural rubber and synthetics, and a guide to ordering. Williams-Bowman Rubber Co., 1945 S. 54 Ave. Cicero 50, Ill.

Circle 53, inside back cover

LIMIT CONTROLLERS—Folder 562, 4 pp. Describes models 561 and 562, how they are used for automatic control of weight, size, force thickness, pressure, flow, acceleration, stress, strain, or other physical quantities. A number of suggested applications are shown. Specifications are given. Daytronic Corp., 216 S. Main St., Dayton 2, Ohio.

Circle 54, inside back cover

ELECTRONIC EQUIPMENT—Catalog Sheets ER-1, F-2, PW-5, LF-1A, P3-RM. Specifications, descriptions and features of, respectively, an edge register detector, direct impulse counter, five selection preset counter, lineal footage counter and readout, and electronic counter. Illustrated with photographs and dimensional drawings. Electronics Div., Post Machinery Co., Dept. 551, Beverly, Mass.

Circle 55, inside back cover

MANUAL MOTOR STARTERS—Bulletin GEA-6358A, 8 pp. Catalogs small-size manual starters for fractional and integral horsepower motors to 7½ hp. Includes new features, application and installation data, and a rating table for plug-in heaters. General Electric Co., Schenectady 5, N. Y.

Circle 56, inside back cover

STAINLESS STEEL SAND CASTINGS—Brochure, 4 pp. Discusses types and applications of these castings. Included is a table of specifications for some common stainless steel alloys. Alloy Steel Casting Co., 249 County Line Rd., Southampton, Pa.

Circle 57, inside back cover

STEEL HUBS AND MALLEABLE SPLIT TAPER BUSHINGS – Catalog HV-101-A, 4 pp. Illustrates and describes 10 stock sizes and three custom sizes of steel hubs to accommodate all sizes of the bushings. Browning Mfg. Co., Maysville, Ky.

Circle 58, inside back cover

CERAMIC MAGNETS—Bulletin RC-11A, 12 pp. Includes diagrams and illustrations of specific uses and their advantages for various applications. Also, graphs plotting every magnetic characteristic of importance. Stackpole Carbon Co., St. Marys, Pa.

Circle 59, inside back cover

FEDERAL ENGINEERING CAREERS—Booklet 112B, 12 pp. Announcement

(Continued on page 171)

of surrently open examinations for engineering positions paying from $4480 to $11,610 a year. Positions are located in Washington, D. C., throughout the U. S., and abroad. U. S. Civil Service Commission, Washington 25, D. C.

Circle 60, inside back cover

ROLLER CHAINS AN SPROCKETS—Catalog 757, 68 pp. Describes and illustrates full stock line. Data on selecting a stock roller chain drive, establishing service horsepower required, determining size of driven sprocket. Diamond Chain Co., Inc., Dept. 443, 402 Kentucky Ave., Indianapolis 7, Ind.

Circle 61, inside back cover

TITANIUM—Booklet, 24 pp. A fact file of information and reference on advantages, physical, mechanical and corrosion properties, metallurgy, machining, production techniques. Tabular information is also included. Mallory-Sharon Titanium Corp., Niles, Ohio.

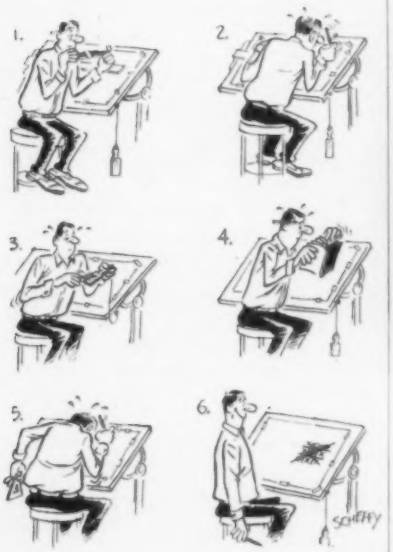
Circle 62, inside back cover

METAL MOLDINGS—Catalog 10 C, 68 pp. Information and specifications on moldings fabricated from stainless and cold roll steel, brass, bronze and aluminum. With photos, diagrams, and dimensional drawings. John Lees Div., Serrick Corp, Muncie, Ind.

Circle 63, inside back cover

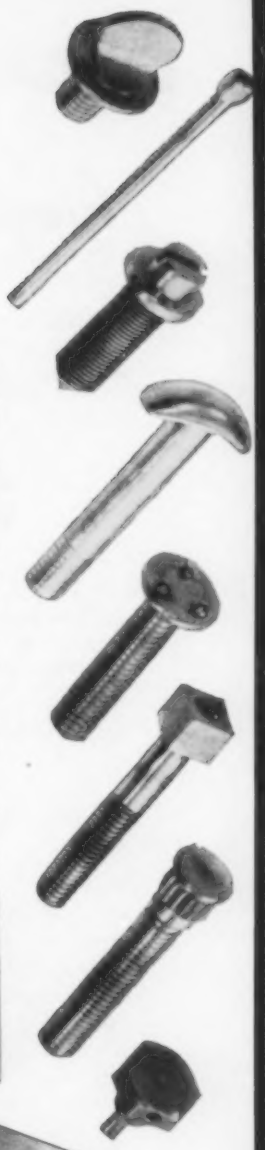
MINIATURIZATION OF SELF-LOCKING NUTS—Brochure 5711, 36 pp. Discusses reduction of fastener size and weight, fastener configuration and the relative importance of each factor. Comparison charts show weight, size, temperature and material for nuts. Text and

(Continued on page 172)



HARPER®

CORROSION-RESISTANT FASTENINGS



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Only Harper, with its vast experience in corrosion-resistant fastenings, could develop Flo-Form—the copyrighted name for an exclusive process that turns out problem specials *better, faster,* and at *lower cost!* Call your nearby Harper Branch and outline your *"special problem"* to a Harper Application Engineer. See how quickly the team of Harper engineering, metallurgical, and tooling specialists speeds the right answer to you. See how Harper Flo-Form produces a cleaner, stronger, better special . . . faster . . . at lower cost! Draw upon our thirty-three years of know-how. Send your problem to The H. M. Harper Company, *today!*

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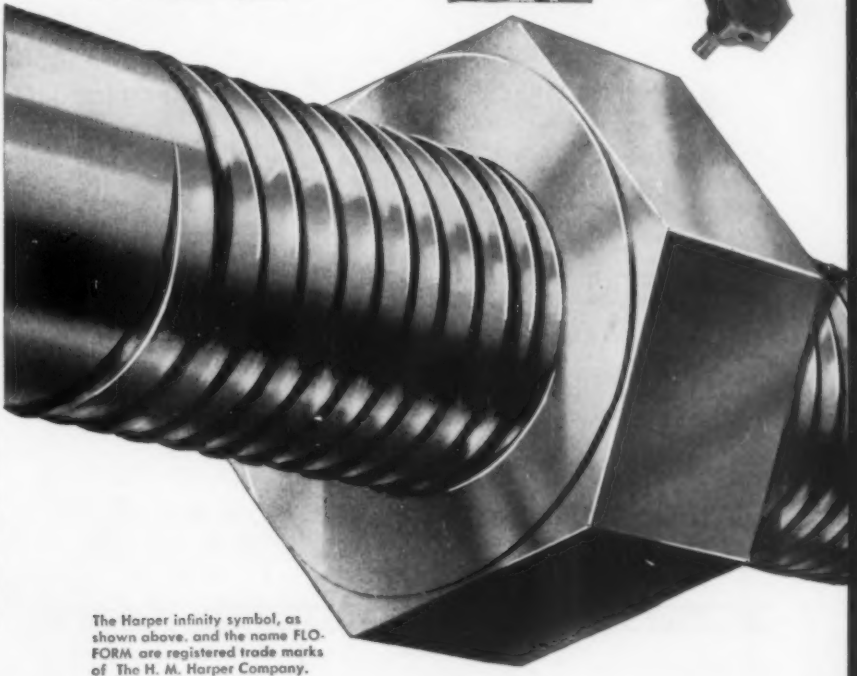
Meet HENRY MULLANEY, Harper Application Engineer

Philadelphia design and production engineers who have called upon Mr. Mullaney for assistance with fastening problems know the value of his advice and counsel. Henry typifies the experience that can be applied to your fastening problems through Harper Flo-Form Engineering Service.



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1 ACCURATE dependable action through millions of cycles.

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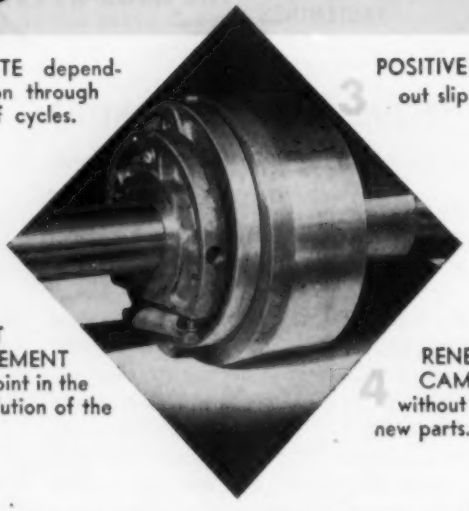

2 INSTANT ENGAGEMENT at any point in the the revolution of the driver.

4 RENEWABLE CAM SURFACES without machining or new parts.

The Hilliard Single Revolution Clutch *is automation* because it provides precise accurate intermittent motion automatically. Control can be electrical or mechanical.

The use of Hilliard Single Revolution Clutches has improved the operation of tube straightening and cut-off machines—shears—conveyors—riveting and fastening units—case loaders—bottle unscramblers—weighing and packaging—indexing and feeding—marking—punching—textile and business machines—radar apparatus—proportionate pumps—and many other types of mechanisms.

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OVER-RUNNING CLUTCHES for automatic instantaneous engagement and release on two speed drives, dual drives and ratchet or backstop action. Ask for Bulletin 231.

SLIP CLUTCHES for overload protection, or constant torque and to provide constant tension and permit speed variation on rewind stands. Ask for Bulletin 300.

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Catalogs and Bulletins.....continued

cross-sectional drawings on basic miniature hex, clinch, fixed and floating anchor nuts. Dept P, Elastic Stop Nut Corp. of America, 2330 Vauxhill Rd., Union, N. J.
Circle 64, inside back cover

ALLOY STEEL AND IRON CASTINGS—Catalog, 24 pp. Methods for casting are described and illustrated. Chemical, physical and similar specifications for the alloys are shown in tables following samples of castings. Howard Foundry Co., 1700 N. Kostner Ave., Chicago 39, Ill.
Circle 65, inside back cover

EXPANDING BLIND RIVET—Booklet, 8 pp. Includes engineering standards drawings, specifications, and catalog numbers. Inside covers show detailed sketches of how the rivet may be applied to various metal-to-metal fastening jobs. Star Expansion Industries, 142 Liberty St., NYC.
Circle 66, inside back cover

RAPID REVERSING MOTOR—Bulletin GEA-6645, 4 pp. Gives design and application information. Illustrated with large cutaway drawing. Has dimensional data and drawings. General Electric Co., Schenectady 5, N. Y.
Circle 67, inside back cover

MAGNESIUM—Catalog, 24 pp. A basic presentation of sand casting methods, illustrated by photos and diagrams. One section discusses the development and advantages of magnesium alloys, with data on mechanical and chemical properties. Howard Foundry Co., 1700 N. Kostner Ave., Chicago 39, Ill.
Circle 68, inside back cover

ALUMINUM AND BRASS CASTINGS—Catalog, 24 pp. Describes equipment necessary and processes. With tabular data on specifications and properties. Permanent mold design points are illustrated. Howard Foundry Co., 1700 N. Kostner Ave., Chicago 39, Ill.
Circle 69, inside back cover

CELLULAR RUBBER—Catalog 762, 28 pp. Discusses properties of and test data on cellular rubber. Includes characteristics, special purpose stocks, specifications, and tolerances. B. F. Goodrich Sponge Products, Shelton, Conn.
Circle 70, inside back cover

HOW TO ELIMINATE CRACKING HAZARDS—Brochure, 8 pp. Gives information on tool making, tool design, heat treatment, and steel selection. Discusses means of eliminating cracking hazards. Carpenter Steel Co., 317 W. Bern St., Reading, Pa.
Circle 71, inside back cover

SELF-LOCKING BOLTS—Folder ADV-792, 4 pp. Principal features and advan-
(Continued on page 177)

MOLY NEWS

CLIMAX MOLYBDENUM COMPANY, 500 FIFTH AVENUE, NEW YORK 36, N. Y.

Ultra-Strength Steels Boost Tensile Strengths to 300,000 psi.

Ten years ago, engineers considered 180,000-psi tensile strength in steels the maximum they could use safely.

Today, alloy steels with minimum strengths of 220,000 to 300,000 psi are being used commercially. These ultra-strength steels have the ductility and toughness needed for structural applications. At tensile strengths above 220,000 psi, they show more strength per pound of product than high-strength aluminum alloys. And at 260,000 psi, they are approximately 15% lighter than aluminum alloy products of the same strength.

Molybdenum is an essential element in almost all of these steels.

How are the higher strengths and strength/weight ratios of these steels being used? Until recently, they've been utilized almost exclusively in aircraft components, such as landing gear. Now, however, they're being considered wherever weight and space savings compensate for higher fabrication costs . . . as, for example, in equipment that must be moved (portable tools); gears, pulleys, belts, liners; heavy machinery operating at high stresses; machinery where inertia is a design factor; materials-handling equipment, such as cranes; and transportation equipment.

Like to know more about ultra-strength steels and their properties, and the names of manufacturers? For our free booklet, circle #1 on the coupon.

Bulletin Shows How to Get Heat Resistance in Cast Iron

In cast iron, heat resistance can mean different things: resistance to growth, to heat checking, to scaling, or to deformation under load at high temperatures.

"Why Moly Iron? #5" contains a chart showing the specific kinds of heat resistance needed by parts such as brake drums, melting pots, piston rings and so on. This chart also lists the best type of iron to use and the proper alloy additions. A number of detailed case histories document this useful bulletin.

For a free copy of "Why Moly Iron? #5" circle #2.

New Coatings May Solve Moly's Oxidation Problem

The most important obstacle to using molybdenum at high temperatures is being overcome. Oxidation is the problem; at temperatures over 1000F, molybdenum oxidizes rapidly.

Newly developed coatings offer molybdenum the needed protection. Three types are promising:

1. Electro-deposited chromium and nickel layers which protect molybdenum to 2000F.

2. Sprayed coatings of aluminum-chromium-silicon alloys, and nickel-boron alloys, which have proved effective at 2000-2400F.

3. Ceramic and molybdenum disilicide coatings which hold promise of protecting molybdenum from oxidation at even higher temperatures.

Digested from "Protecting Molybdenum at High Temperatures" by Julius Harwood, Materials & Methods. For reprint of entire article, circle #3.

Booklet Deals with Molybdenum Joining Techniques

Recent progress in joining molybdenum, and suitable means for protecting it from oxidation, are opening up new uses for molybdenum and its alloys in structural components for high-temperature service.

"A New Look at Joining Molybdenum" by R. R. Freeman and J. Z. Briggs, both of Climax, analyzes the factors involved in joining moly and discusses the methods available.

For the free booklet, circle #4.

List of Moly Literature Now Available

Copies of more than 30 recent pieces of technical literature on molybdenum are available from Climax Molybdenum Company. *For a free list of these, including titles, authors, sources and 25-30 word summaries, just circle #5.*

Steels for Power-Plant, Refinery Equipment at 900-1100F

Designers of power-plant and refinery equipment who need to select steels for applications at 900 to 1100F will be interested in a copy of "Chromium-Molybdenum and Chromium-Molybdenum Vanadium Steels for power-plant and refinery service up to 1100F."

This paper, presented at the ASME annual meeting by George V. Smith, Bard Professor, Cornell University, appraises literature on the subject and draws some new, objective conclusions.

For a free reprint, circle #6.

New Climax Alloy Proves Unusually Wear Resistant

These liner castings, made of Climax 321, proved highly resistant to wear in our ball mill discharge launders. Severe wear normally occurs in this operation as a result of erosion from the coarse pulp flowing out of the ball mill discharge.

If you need a highly wear-resistant material, you may be interested in our new Climax 321 Alloy. It's a hard, martensitic type of white iron containing nickel, chromium and molybdenum in proportions that are well balanced, both metallurgically and economically.

We've been using 321 Alloy in our own mining operations with exceptional results. Comparative tests in ball mill liners and grinding balls proved its excellent wear-resisting properties.

Because this alloy is relatively new, service results in other applications are not yet available. However, our laboratory studies and data indicate it should prove suitable for the general run of abrasion-resistant castings of the martensitic white iron type—such as wear shoes, sand and dredge pump wearing parts, pug mill knives, mixer liners, etc.

Climax 321 can be melted in a cupola or electric furnace and cast in either sand or permanent (chill) molds. It has a normal hardness range of 55 to 62 Rockwell "C".

Composition: Carbon 3.30-3.60%; Silicon 0.30-0.60; Manganese 0.50-0.80; Nickel 2.75-3.25; Chromium 1.75-2.25; Molybdenum 0.70-1.10; Sulphur 0.15 max.; Phosphorus 0.30 max. *For data sheet, circle #7.*

Climax Molybdenum Company, Dept. 61
500 Fifth Avenue, New York 36, N. Y.

I'd like more information on:

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Company_____

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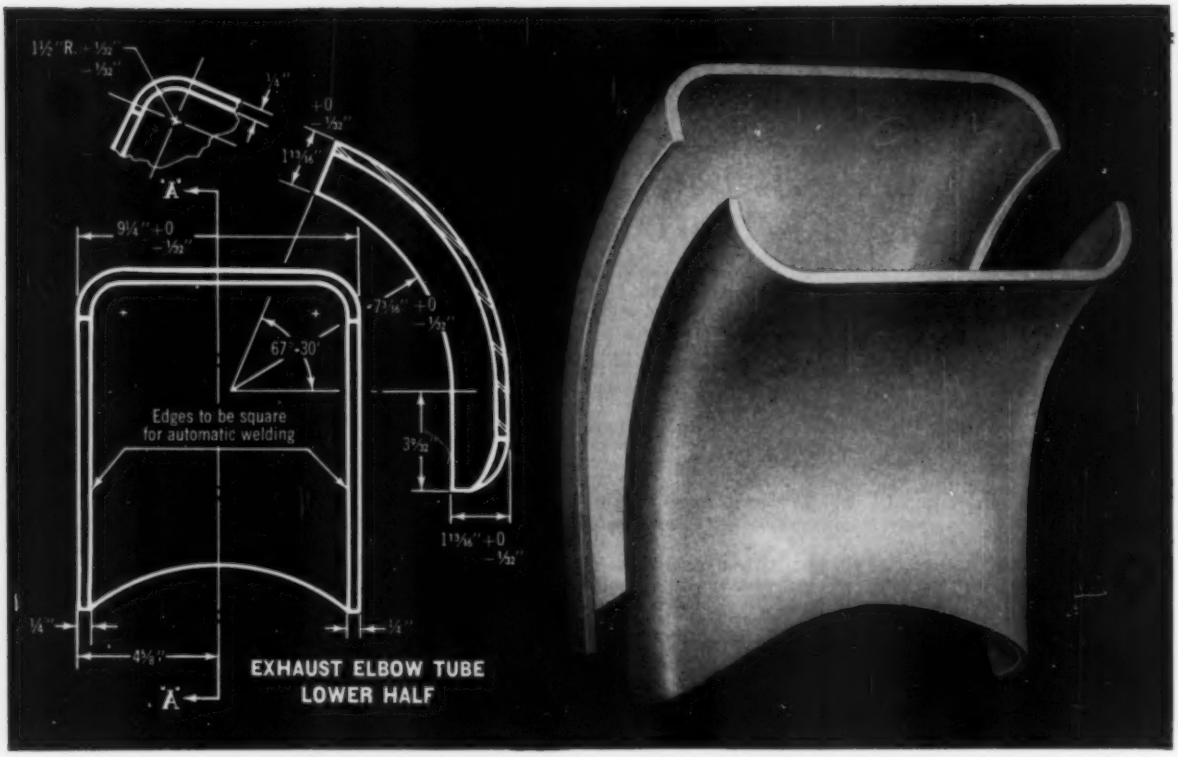

Stamping tolerances held +0 -1/32" solve tough design problem

Previous attempts to fabricate diesel locomotive exhaust elbows by stamping had proved unsatisfactory. Tolerances necessary for production welding of the parts could not be held. Too many bad welds resulted and rejects piled up. Forging the part from hot rolled seamless tubing likewise proved too expensive.

Commercial engineers proved the elbows could be turned out as stampings and now Commercial is producing them from 1/4-inch flat steel with accurate tolerances of +0 −1/32.

These close tolerances are important because the two halves of the elbow are welded together automatically. If the opening between the parts is too wide, the weld metal will not bridge the opening. If it is too narrow, the metal will not penetrate the joint properly.

The accuracy of the Commercial dies also assures exact fit of both the square end of the tube, which is welded to the engine block opening, and the curved end, which is welded to a cylindrical manifold. No trimming of these ends is necessary.

The end result is consistently strong even welds at all points, few rejects, faster assembly. By switching from hot rolled tubing at 15 cents a pound to mild flat steel at 6 cents a pound, a substantial cost saving was also effected.

Custom stamping to very close tolerances of even very large or complex parts has long been standard operating procedure at Commercial.

We invite you to submit your blueprint, sketch, or sample for study. Commercial engineers can advise you without obligation on ways and means to improve the component parts. Very often slight design modification makes possible the use of Commercial's "die-bank" of over 2300 basic die components, resulting in substantial savings in the overall cost of the part.

Address inquiries or requests for forming engineering assistance to The Commercial Shearing and Stamping Company, Dept. G-38, Youngstown 1, Ohio.

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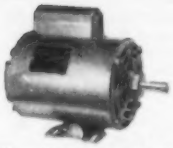
Reduce Down Time—Power your Product with *Dependable* Wagner Motors

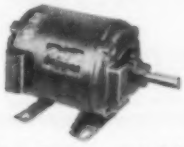
Sixty-six years of experience goes into the building of Wagner Motors. Their reputation for reliability, their electrical characteristics, price and prompt delivery make them a sound choice for your product.

Whatever your motor requirements may be—single-phase or polyphase... ⅛ or 500 horsepower—Wagner can offer a standard motor that is entirely dependable in its specific application. A few of the many motors in the Wagner line are shown below.

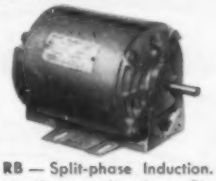
FRACTIONAL HP



TYPE RK — Capacitor-start Induction. For general purpose applications. Single-phase. Rigid or resilient mounting. 48 frame: ⅛ or ¼ hp. 56 frame: ⅓ through ¾ hp. Also available in integral ratings through 5 hp.



TYPE RA — Repulsion-start Induction. For general purpose applications. Single-phase. High starting torque—low starting current. ⅛ through ¾ hp. Also available in integral ratings through 15 hp.



TYPE RB — Split-phase Induction. For easy starting applications. Single-phase, resilient mounting. 48 frame: ⅛, ¼ or ⅓ hp.

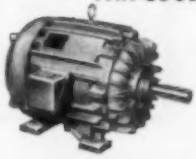
TYPE RP — Polyphase Squirrel-cage Induction. General purpose, normal torque. 56 frame: ¼ through ¾ hp.

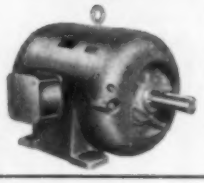
INTEGRAL HP

DRIP-PROOF

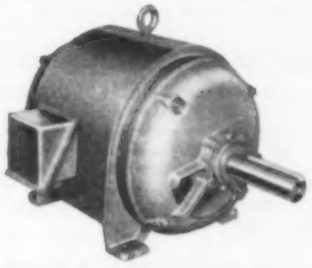
TYPE DP—Squirrel-cage Induction, corrosion resistant cast iron frames. 1 through 125 horsepower.

TOTALLY ENCLOSED FAN-COOLED





TYPES EP AND JP Standard and explosion-proof. Squirrel-cage Induction, corrosion resistant cast iron ribbed frames, 1 through 30 hp—smooth frames, 40 through 250 hp.



OPEN TYPE POLYPHASE SQUIRREL CAGE

TYPE RP—Drip-proof. Suitable for all general purpose applications. Available in ratings 150 through 500 hp.

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In addition to a complete line of standard motors, Wagner also furnishes Increment Type Motor and Starter Combinations... Wound Rotor Polyphase Motors... Jet Pump Motors... Vertical and Flange Mounted Motors... Hermetic Motors... Gear Motors and Direct-Current Motors. Consult the nearest of our 32 branch offices, or mail coupon today for full information on the complete Wagner line.

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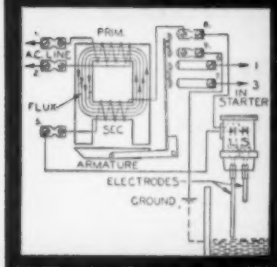
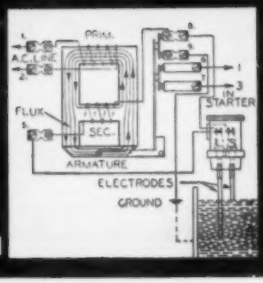
LIQUID LEVEL CONTROL
with the
B/W RELAY





Type LH Relay
for
Pump Down Control

POSITIVE AND DEPENDABLE

The B/W system of liquid level control consists of a transformer type induction relay and a holder for one or two electrodes, depending on the desired operation and the type of relay used. The relay incorporates a primary or line voltage coil connected to a permanent source of alternating current, and a secondary or electrode circuit coil connected to the electrodes immersed in the liquid being controlled. Energizing the primary coil causes an induced voltage in the secondary coil; thus the secondary coil is never connected to the power line.

LIQUID IS ELECTRICAL CONDUCTOR

The liquid itself is the electrical conductor that completes the secondary circuit. When this secondary circuit is completed, by the liquid contacting both electrodes, the magnetic attraction set up in the legs of the relay core causes the armature to close, and open or close the load contacts. A built-in holding circuit maintains this contact until a predetermined fall in liquid level breaks the circuit. By adjusting the electrode settings, the range of operation can be controlled.

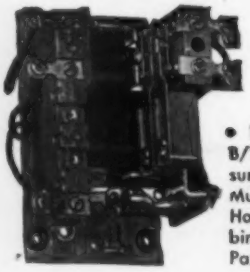
FOR PUMP UP and PUMP DOWN APPLICATIONS, SIGNALS and ALARMS

B/W relays are designed for either pump up or pump down operation. In addition, by using a single electrode they are well suited for signal and alarm applications.

NO MOVING PARTS

The complete absence of moving parts in the liquid insures long and trouble-free performance. Because of the very low current in the secondary circuit these relays are ideal for many switching jobs outside of the liquid level field.

Consult our engineering department on any special control applications.



CATALOG
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- It covers the complete line of B/W Induction Relays, Enclosures, Contactors and Starters, Multiple Pump Controls, Electrode Holders, Starter and Relay Combinations, Special Controls and Panels.

B/W CONTROLLER CORPORATION
2218 E. Maple Road, Birmingham, Mich.

FIRST IN THE FLOATLESS CONTROL FIELD

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This is but one example of MOLYKOTE's effectiveness in industry. Here are others:

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- . . . increased cycles from 28,000 to 700,000 in tests on brass taper air valves. (Field Report 4)
- . . . raised Oilite bearing life from 6 to 46 hours. (Field Report 24-47)
- . . . raised life to failure time from 120 to 400 hours on sintered bronze bearings; reduced wear in 12 hour test from .002 to .001. (Field Report 43)

MOLYKOTE Field Reports are filled with thousands of these case histories. Write for your copies . . . but be sure to mention your application.

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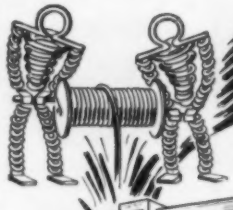

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4014 W. Grand, Chicago 51, Ill.

tages are described. Includes drawings and a table showing installation and static torques. Republic Steel, Adv. Div., 3100 E. 45 St., Cleveland 27, Ohio.

Circle 72, inside back cover

PNEUMATIC CONTROL — Bulletin A130, 44 pp. 10 pages of general automatic control theory with illustrations. Describes Series 500 pneumatic recording and indicating controllers and sensing elements used with the instruments. Final control elements and accessories are listed. Bristol Co., Waterbury 20, Conn.

Circle 73, inside back cover

PLASTIC PIPE—Catalog 401, 10 pp. Covers the development, application, installation and specifications of SP plastic pipe, made from a new polyethylene resin. Illustrated with charts and diagrams. Orangeburg Mfg. Co., Inc., Orangeburg, N. Y.

Circle 74, inside back cover

PRESSURE-MEASURING DEVICES — Bulletins 1547 A, CEC-1573, 1581, 1568 A. Gives general descriptions, specifications, and operating principles of instruments serving various pressure-measuring needs. Illustrated with diagrams, photos and charts. Consolidated Electrodynamics Corp, 300 N. Sierra Madre Villa, Pasadena, Calif.

Circle 75, inside back cover

FASTENINGS—Catalog, 24 pp. General catalog of hot and cold forged parts. Shown are examples of parts produced. With dimensional drawings, specifications, standardized specials, operational data, a practical guide for designing cold headed shapes. H. M. Harper Co., Morton Grove, Ill.

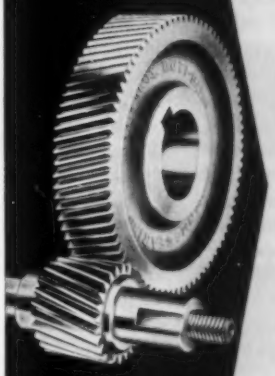
Circle 76, inside back cover

"Another way you could attract design engineers, Mr. Biglow—offer money."

PREMIUM GEARING
at Production-Run Prices

Foote Bros. Offers Engineered Helical and Worm Gear Sets FROM STOCK

1638 Duti-Rated COMBINATIONS



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*Center Distances.....2" to 12"**

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When you buy Duti-Rated Gearing, you'll get more than best for your money . . . you'll get the benefit of thousands of engineering and development hours . . . and the unquestioned advantages of precision tooling and manufacturing methods. You'll get performance proven in countless Foote Bros. Line-O-Power and special drives, and Foote Bros. —Louis Allis Gearmotors. This is high hardness, accurate, balanced design gearing that will give you more load capacity and wear life per dollar.

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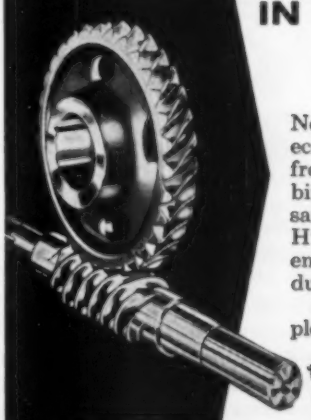
150 WORM GEAR COMBINATIONS



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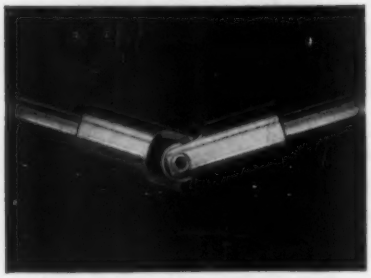
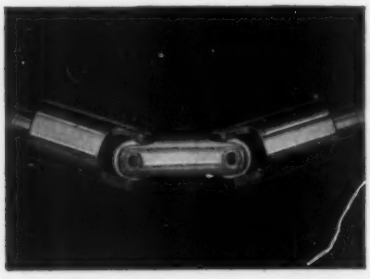


This single universal joint in a ribbon-stripping machine was operated at a 34° angle. The joint heated up, wear was excessive. (Curtis Joints have been tested at angles up to 37°, but we do not ordinarily recommend angles greater than 30°.)



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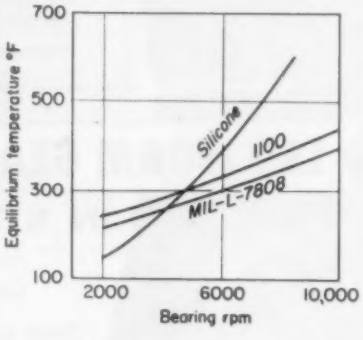
DESIGN ABSTRACTS

Developments in Aircraft Turbine Lubricants

A number of basestock materials, with suitable additives, have been screened for high temperature lubricant potential. Tested were esters, mineral oils, silicones, silanes. At this time, esters and mineral oils appear to be the most promising high temperature candidates. The silanes and silicones also have very interesting properties, but their current defects will have to be corrected.

Silicones showed an alarming instability (see chart). Normally, a given size anti-friction bearing when operated at a specific speed, lubricant flow and known viscosity lubricant, will stabilize at some predictable temperature. This has been found true of both mineral and ester lubricants. The



reasons for such unpredictable bearing stabilization temperatures with silicones is unknown at this time. Another drawback of silicones is poor wear resistance with both steel and carbon.

Other than laboratory studies, very little mechanical or rig data has been obtained on silanes, either alkyl or aromatic. But both types show poor wear-resistance properties compared to mineral and ester based lubricants.

Esters and mineral oils show considerable promise as future lubricants. The term "ester" includes a multitude of organic materials, e.g. MIL-L-7808 oils are diesters, and for high temperature oils need further definition. At the present, diester, fluoresters and pentaerythritol esters are the most promising ester candidates. However, one almost universal property of promising high-temperature candidates is relatively poor low-temperature properties compared to MIL-L-7808 oils. It appears that the price of high-temperature lubricant performance may well have to be a compromise of low temperature lubricant performance. Some investigators believe that a relaxation of 1 F at low temperatures (— 65 F) may be reflected in a 2 or 3 F gain in high temperature (bulk oil) performance. Very limited engine data appears to substantiate this "rule of thumb" with the materials so far investigated.

Abstracted from "Developments in Aircraft Turbine Lubricants," by T. F Davidson and J. H. Way, Society of Automotive Engineers, April 2-5, 1957.

Reducing Residual Stresses

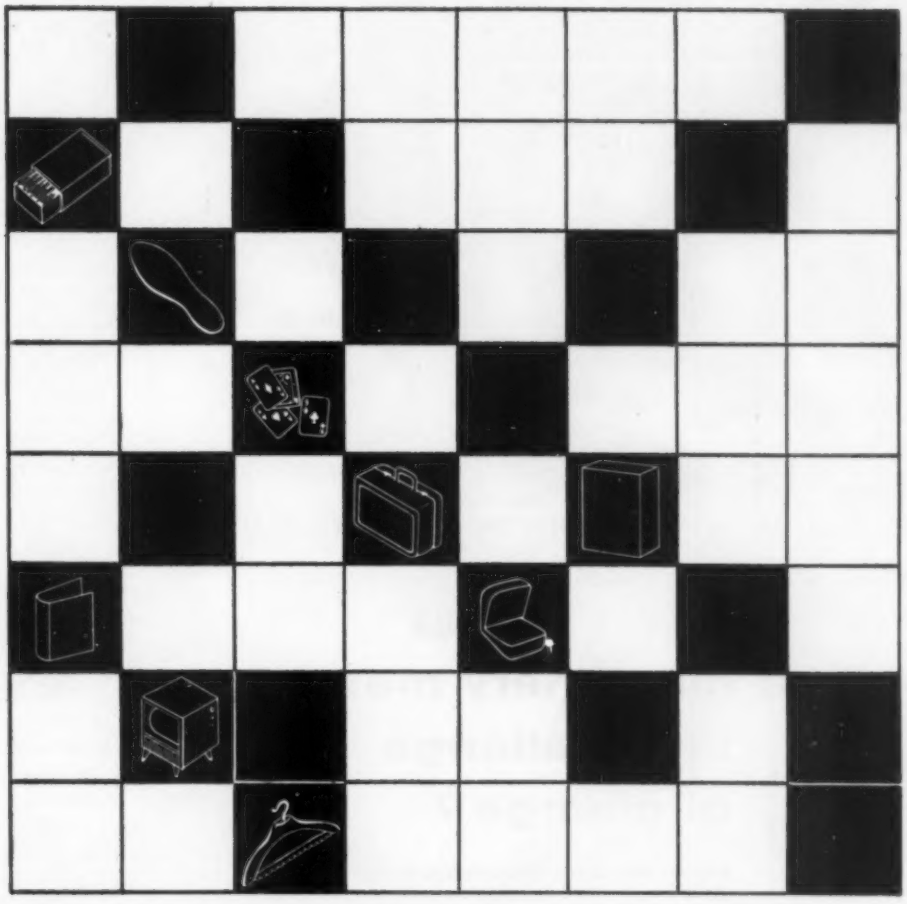
Residual stress caused by grinding high-temperature alloys has proved to be a double problem: distortion of the parts, and reduced endurance limits. A complete analysis measured the effects of grinding-wheel speed, grinding-wheel hardness, grinding fluid, down feed, and work speed on the residual stress level in the surface of three alloys used in modern aircraft gas-turbine design. Results of the study show stresses can be minimized by reducing wheel speeds and down feeds, increasing work speed, and using a sulphurized oil as the grinding fluid.

Abstracted from "Analysis of Residual Stress in Ground Surfaces of High-temperature Alloys," by R. D. Halverstadt, General Electric Co., Cincinnati, 15. ASME Paper No. 7-Sa-62, June 9-13, 1957.

Overcoming Problems in Hydraulic Control

To achieve a high-performance hydraulic servo and provide adequate servo damping, oil in the transmission lines to and from the pump, as well as oil in the servo loop, must be treated as a dynamical element. By methods of analysis similar to those used for electrical systems it can be shown that hydraulic fluid flowing through tubes possesses properties remarkably analogous to electrical re-

(Continued on page 180)



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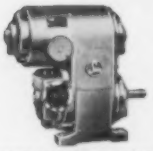

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sistance, capacitance and inductance. These properties are presented here without derivation.

$$R_H = \frac{128\mu x}{D4}$$

$$C_H = \beta A X$$

$$L_H = \frac{\rho \ell}{A}$$

Where R_H = Hydraulic resistance per unit length X
C_H = Hydraulic capacitance per unit length X
L_H = Hydraulic inductance per unit length X
μ = Absolute viscosity
D = Tubing inside diameter
A = Cross sectional area of flow path
β = Compressibility factor
ρ = Mass density

Using these parameters, the dynamics of hydraulic transmission lines can be analyzed by essentially the same techniques as are used for electrical transmission lines.

As most aircraft hydraulic oils undergo wide changes in compressibility over expected operating temperatures, servo stability usually requires that the volume of hydraulic fluid under compression be held to a minimum.

Fluids—The wide range of operating temperatures encountered in aircraft hydraulics has led to the consideration of stable synthetic fluids to replace petroleum oils in aircraft hydraulic systems. Of these synthetics the silicate esters have received by far the greatest acceptance. Other fluids with potential are silicones, polyglycol esters, fluorocarbons and dibasic acid esters.

None of the high-temperature fluids being considered appears to have any significant oxidative stability and relatively little thermal stability at temperatures above 500 F. Most tend to form sludges when subjected to heavy shear loads at high temperature.

Radiation—System designers are just becoming aware of some of the problems to be faced when hydraulic components must be made compatible with nuclear irradiation.

The two primary causes of degradation in hydraulic systems materials are irradiation by gamma rays and bombardment by neutrons. This is further complicated by the wide speed range of neutrons. Fast neutrons have a markedly different effect on materials than slow or "thermal" neutrons.

The principal organic materials af-

(Continued on page 183)

"THE CRUX OF THE HONEYCOMB SANDWICH WILL ALWAYS BE THE BOND"

*B-58 bomber designed and built by the Convair Division of General Dynamics Corporation, Fort Worth, Texas.

B-58 engine nacelle section. Stainless steel honeycomb structure whose light weight is evident. Its strength and aerodynamic qualities are attested to in flight in the world's fastest jet bomber.

This is a direct quote from a recent article on honeycomb structures in *Aeronautical Purchasing* magazine. It states exactly what authorities in the field of supersonic speeds already know, and clearly points up the aims and activities of Handy & Harman in this critical and challenging field.

One of the most significant applications of the honeycomb sandwich can be found in the United States Air Force new supersonic bomber, the B-58.* Elements of this "missile with a man in it" are made of high-strength stainless steel honeycomb sandwich, *bonded* with Handy & Harman special silver brazing alloys – a method which permits honeycomb assemblies of virtually any size.

The honeycomb principle needs no further testimonial. Indeed, the problems it solves and the obstacles it overcomes *now* can mean only that its future is immensely promising. Work with all kinds of materials; metals, ceramics, plastics, paper, etc., is now in progress to further increase its present great values.

Handy & Harman, with its knowledge and facilities in the field of joining metals, can be of great help to you in many of these honeycomb sandwich research areas. Many of the developments in silver alloy brazing, heating methods, production techniques and the formulation of special alloys for special needs, were originated by Handy & Harman. Your efforts in devising new methods in metal joining and in meeting present bonding needs can be helped, in large measure, when you call on Handy & Harman.

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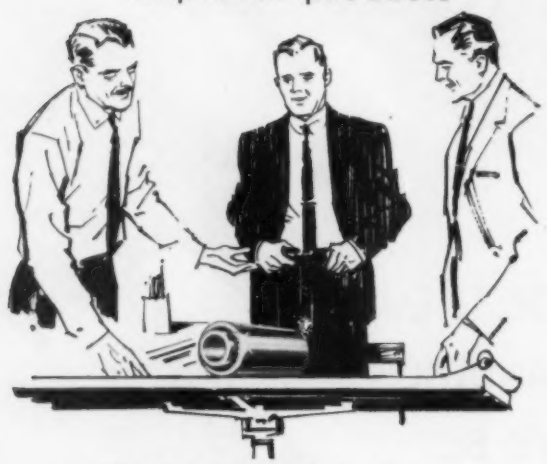

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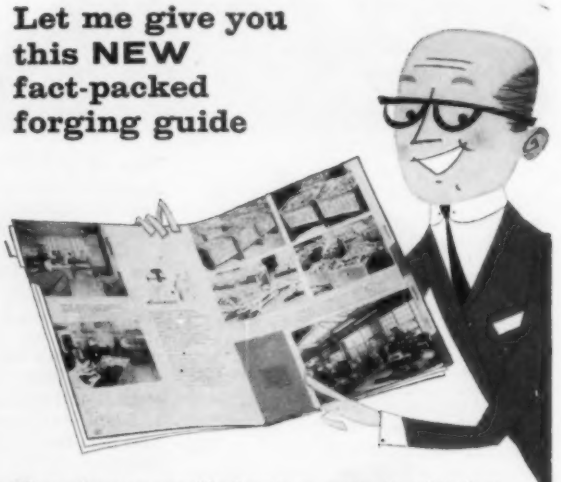

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fected by gamma flux are the hydraulic fluid and the elastomeric seals. Hydraulic fluids are probably mostly affected by cross-linking, which causes changes in fluid viscosity and could eventually result in the fluid's turning solid. Evolution of hydrogen gas which accompanies cross-linking is very serious in hydraulic systems that power high-performance servomechanisms. The free gas markedly increases the effective compressibility of the fluid under compression.

Perhaps the greatest potential design hazard comes from increases in brittleness in ferrous metals. Fast neutron bombardment lowers metal ductility and raises the brittle transition temperature.

Abstracted from "Overcoming Some of the New Problems in Hydraulic Control," by George R. Keller, Autonetics Div., North American Aviation, July, 1957.

How to Improve Systems Engineering

A new kind of education is proposed here, designed to produce persons with competence in a number of scientific disciplines required by systems engineering. Methods suggested for improving communication include universal application of functional and detail block diagrams; increased, more effective use of mathematics as a language; increased attention to editing and summarizing technical articles—with company training programs designed to promote these ends.

In the future, almost every indus-

(Continued on page 184)

"All I said was, 'That's exactly the design I had in mind'!"

THE SHAPE OF THINGS IN MOLDED SILICONE

MOLDED SILICONE SEAL KEEPS TAP WATER UNDER CONTROL

APPLICATION:
Funnel seal for steam and dry iron.

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When this part was originally designed, Silicone rubber compounds with low shrinkage characteristics were not available. This resulted in a twofold problem; first, to produce a compound that would have excellent resistance to all types of tap water and would retain its sealing properties even if the iron were inadvertently run dry; secondly, to construct or match tooling to the characteristics of the compound.

SOLUTION:
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trial process that can be reduced to a set of sequences of logical steps will be done automatically.

The problem of effectively coordinating complex system developments can be attacked by improving communication and employing persons better equipped to work in multiple areas. Many aspects of coordination are identical with the technical problem of logical design of digital computers, hence training in the methods of mathematical logic applied to system design should increase substantially the efficiency of the coordinator.

Systems engineering hinges on seven basic steps: (1) task definition, (2) development of alternative approaches, (3) development based on the best alternative, (4) optimizing by weighting procedures, (5) organization of test and maintenance procedures in parallel with system development, (6) pinpointing essential research and carrying it out, and (7) planned cross checks and independent monitoring of system development activity.

Abstracted from "How to Improve Systems Engineering," by John N. Warfield, University of Ill. Aeronautical Eng. Review, July '57.

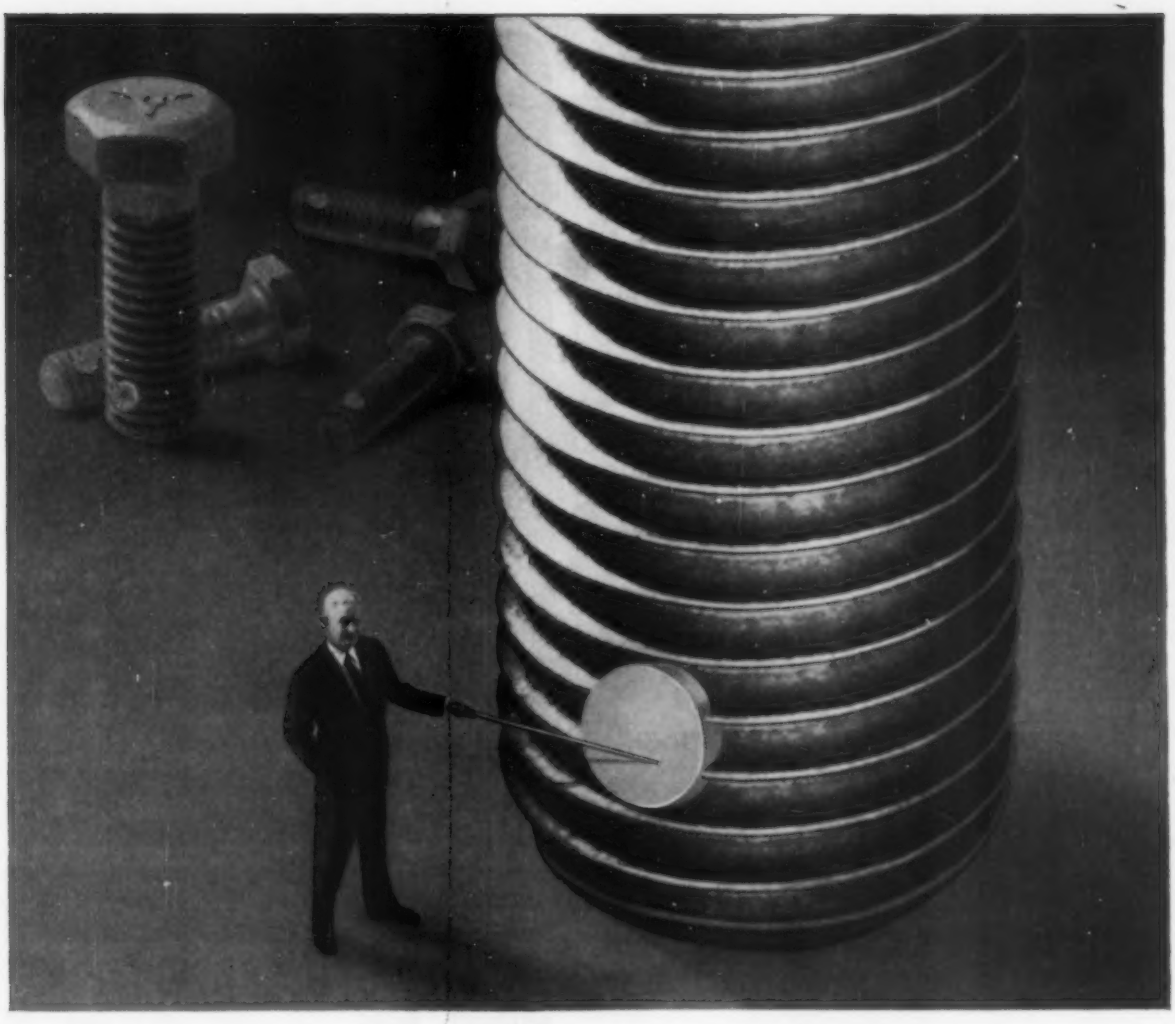
Stiffness of Shafting

Two factors to be considered in line-shaft design are the bending and torsional deflections caused by operational loads. Bearings spaced according to S (spacing) $= 5D^{\frac{4}{5}}$, can limit the degree of bending to about 0.01 in. per ft run of shaft for overhung shafts. This assumes a permissible stress of 6000 psi for the steel shaft. Another formula is necessary for straddle-mounted shafts, where the load is taken between the bearings.

Actual deflections in inches can be calculated by other formulas: maximum deflection, deflection at load point, and point of actual deflection are given by $(WAC^2)/(3EIL)$, $WA^2B^2/(3EIL)$ and $B\sqrt{B + 2A})/3B$ respectively, where W = load in lb; L = length between supports in in.; E = modulus of elasticity; I = moment of inertia of section.

Torsional deflection formulas and table of the polar moment of inertia simplify calculations for deflection caused by torque loads.

Abstracted from Mechanical World and Engineering Record, Aug. '57.



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NEW BOOKS

Fatigue, Creep and Rupture Properties of Heat Resistant Alloys

PB 121580, F. H. Vitovvec and B. J. Lazan, University of Minnesota for WADC 8½ x 10½ in., 195 pp, paperbound. Available from U.S. Dept. of Commerce, Office of Technical Services, Washington 25, D. C. $5.50.

The failure of compressor and turbine components at elevated temperatures due to creep, stress rupture and fatigue continues to be a major problem. Summarized in this report are data on the static and fatigue properties of both unnotched and notched specimens of alloys of current interest. These alloys include: Stellite 31, S-816, 6.3% Mo-Waspalloy, M-252, Inconel X-550, Timken 16-26-6, Crucible 422 and Type 403 Stainless.

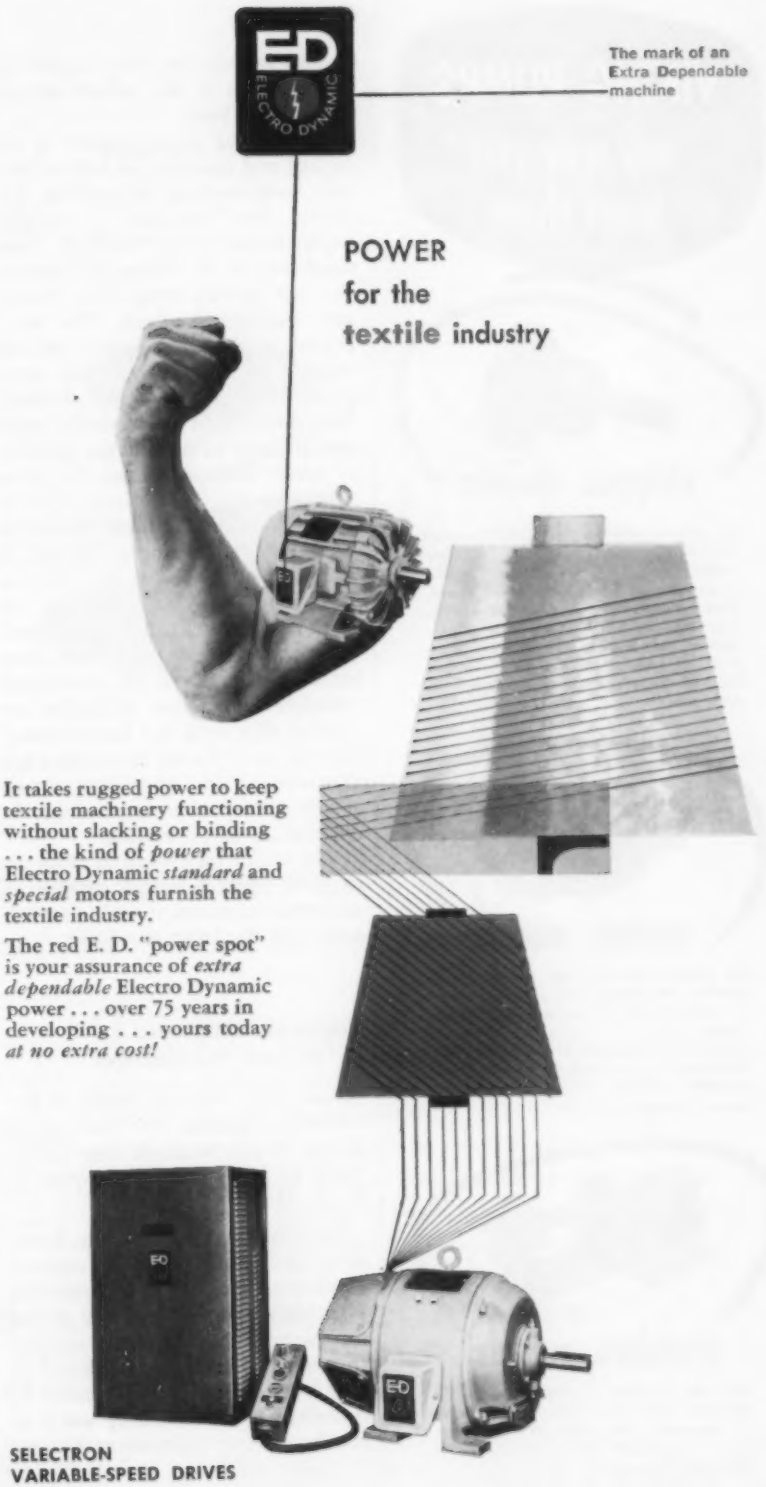
The data are presented as S-N curves and stress range diagrams to show the effect on the fatigue and creep properties of specimen notch, temperature, ratio of alternating-to-mean stress, and stress magnitude. The role of both creep and fatigue as design factors and the relation of notch sensitivity to loading conditions are discussed with particular reference to temperature and ratio of alternating-to-mean stress.

Procedure Handbook of Arc Welding Design and Practice

6 x 9 in., approx. 1240 pp. Published by The Lincoln Electric Co., Cleveland 17, Ohio. $3.

In this eleventh edition, this book attempts to provide useful information on all phases of arc welding: for the machine designer, the structural engineer, the architect, the fabricator, the welder, the supervisor, the inspector, the industrial engineer, the metallurgist, the contractor, the student, and all others interested in any way in metal joining. This edition has not departed from the general form of past editions. The information in the eleventh edition on all phases of arc

(Continued on page 188)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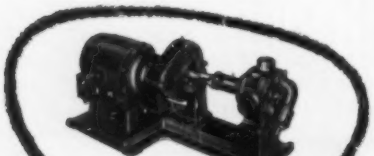

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welding includes the many significant developments in the industry during the past five years.

The newest in equipment is explained and discussed, as well as how new understanding of welding has created new concepts in machine requirements and performance. New developments in electrodes, namely the iron powder type, have created new operating standards. The background of this development and its significance is explained and completely new procedures are detailed. New information on electrode selection attempts to simplify the question of which electrode to use for given applications.

The trend to automatic hidden or submerged arc welding is reflected in an enlarged section on this process. New equipment and procedures are discussed for both fully and semi-automatic processes. New fluxes have extended the fields for the process and complete information is detailed on welding alloy steels and hardsurfacing. Manual hardsurfacing information has also been brought up-to-date, as well as information on many other specific applications of arc welding.

The section on weldability of metals has been edited to include new metals and tables have been revised in accordance with the latest standards.

Engineers Employed by Private Practitioners

Sponsored by National Society of Professional Engineers, 6 x 9 in., paperbound, 40 pp. Available from NSPE, 2029 K St., NW, Washington 6, D. C. $1.

Basic information on salaries, hours, geographic distribution of engineer employees, size of the consulting firms, fringe benefits, length of the work-week, and overtime pay practices are contained in this report. Based on data from questionnaires returned by consulting firms, the survey was a research project undertaken by the Engineers-in-Employ-of-Private Practitioners Subcommittee of the National Society's Employment Practices Committee. Consulting firms surveyed ranged in size from those employing one engineer to those which employ as many as 300. The questionnaires returned represent data for a total of 6,407 engineers—all employees of consulting firms, as distinct from owners and partners.

Median salaries summarized in the report are based on the eight grades of NSPE's "Recommended Grades, Duties, Responsibilities and Qualifications for Pre-Professional and Professional Positions." The median monthly salaries for the eight grades range from $358 to $987. These salary figures do not include the payment of bonuses, which is a common practice in consulting firms.

The most popular fringe benefits listed in the report are paid vacations, bonuses, hospitalization insurance, life insurance and profit-sharing. The standard work week of most of the consulting firms is reported as 40 hours, but 5.8 per cent stated they work less than 40 hours, and 28 per cent reported a work week of 41 to 44 hours.

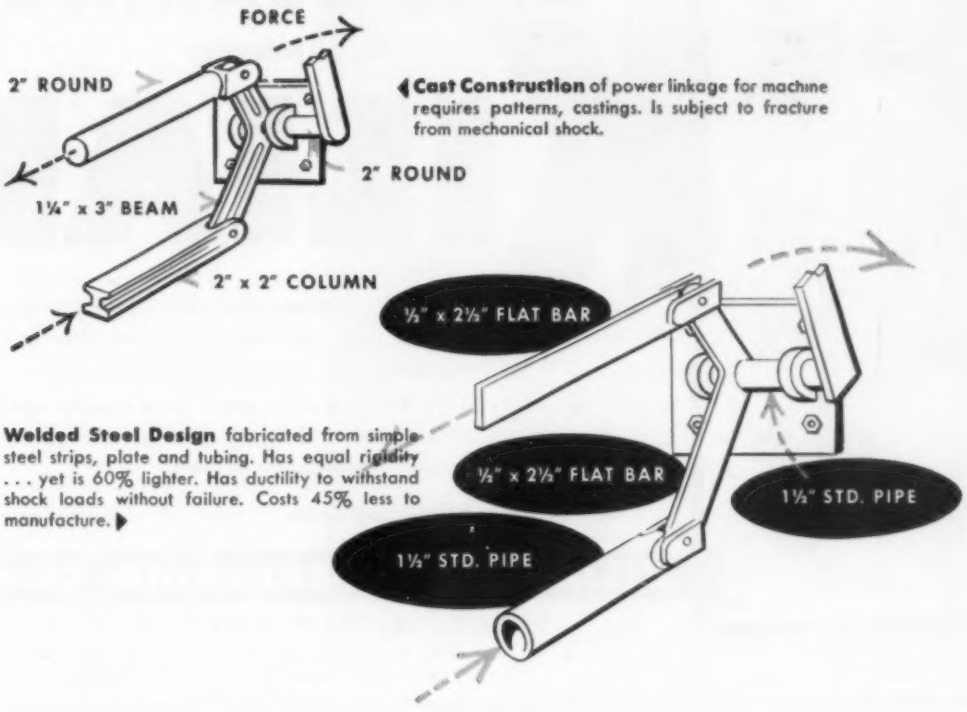
Proceedings of the RETMA Symposium on Applied Reliability

8½ x 11 in., 105 pp plus 46-page supplement, paperbound. Published by Engineering Publishers, GPO Box 1151, New York 1, N. Y. $5.

Papers delivered by leading engineers at the RETMA Symposium on Applied Reliability held in December 1956 are published here in their entirety. The papers describe methods of reliability evaluation, improvement, and prediction. Subjects include the application of mechanical engineering

(Continued on page 191)

"Figuring racing odds isn't Acme's idea of a major engineering problem, Jenson . . ."



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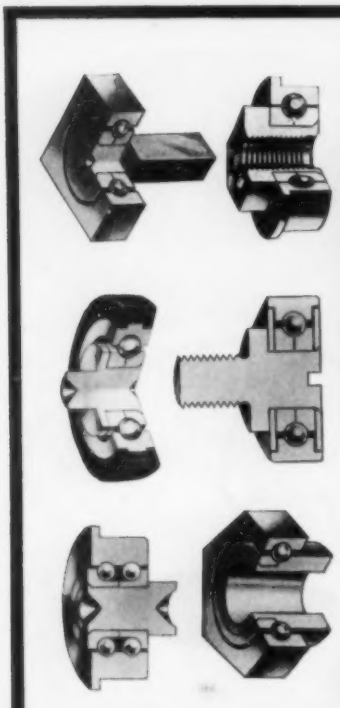

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principles to electronic equipment, cosmic-ray effects on transistors, failure-reporting systems, sampling systems for field data reporting, effective field-failure information feedback, acceptable radar reliability without component part improvement, proper application of component parts, heat dissipation in electronic tubes, measurement of equipment effectiveness, trouble correction in a reliability program, design techniques to achieve reliability, and design considerations of a 10 w transistorized servo amplifier.

A supplement entitled "A General Guide for Technical Reporting of Electronic Systems Reliability Measurements" prepared by members of the Systems Reliability Analysis Task group of RETMA's Electronic Applications Committee (Reliability) is included.

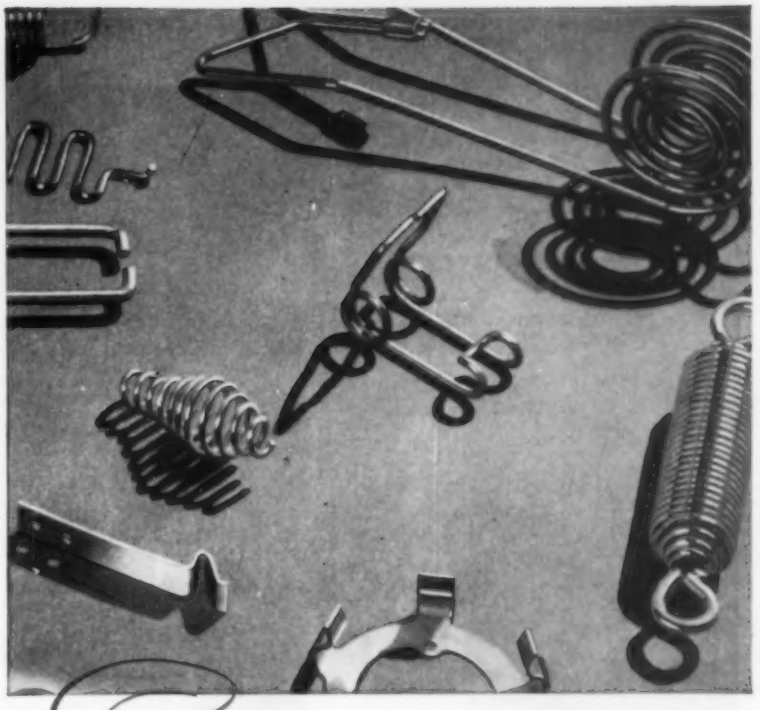
Differential Equations in Science and Engineering

HAROLD WAYLAND, *Div. of Engineering, California Institute of Technology. 6 x 9½ in., 353 pp. Published by D. Van Nostrand Co., Inc., 120 Alexander St., Princeton, N. J. $7.50.*

This book has been prepared primarily as a text book for advanced undergraduates and beginning graduate students in applied science and engineering. It has been designed to follow a two-year course in calculus and analytic geometry and a basic course in physics in which the methods of the calculus have been introduced. It has been normally used concurrently with upper division courses in mechanics, electricity and magnetism, fluid mechanics and thermodynamics. At this stage of development, the student is prepared to look at the whole process of solution of a physical problem by means of mathematics, from the translation of the physical concepts into mathematical language, through the formal solution to consideration of the physical reasonableness of the result.

Although differential equations represent the central theme, many topics in advanced calculus are included. Vector concepts receive full attention, since they are useful in deriving certain partial differential equations, and

(Continued on page 193)



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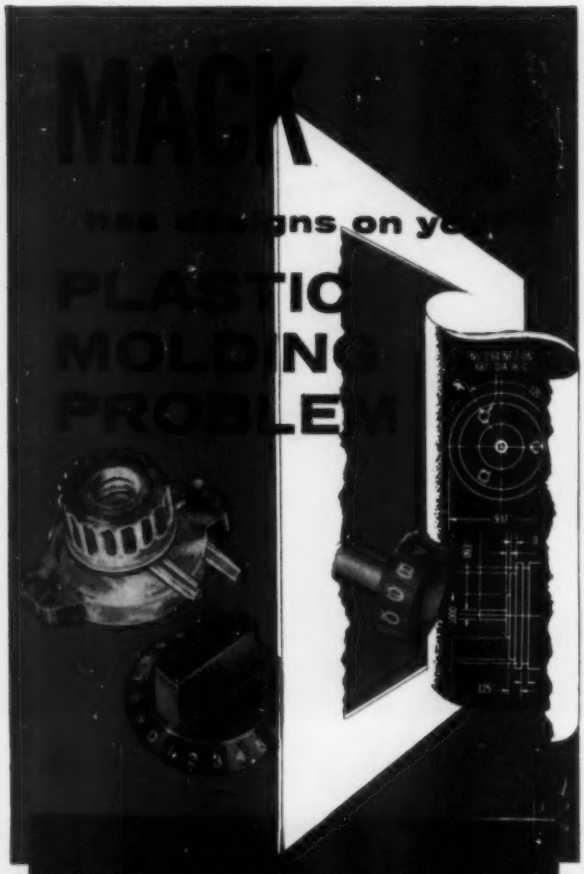

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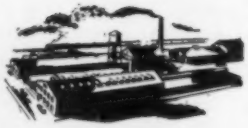

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Electronic Components Handbook

Edited by KEITH HENNEY & CRAIG WALSH, *Technical Writing Service, McGraw-Hill Book Co., prepared for Electronic Components Laboratory, Wright Air Development Center.* 8½ x 11 *in.*, 224 *pp. Published by McGraw-Hill Publishing Co.*, 330 W. 42 *St.*, N. Y. 36, N. Y. $9.

This book gives a general description of all types of resistors, capacitors, relays, and switches and describes the uses of particular types. The effect of unfavorable environment such as heat, humidity, high altitude, low pressure, shock, vibration, on each type of component is discussed.

The book concentrates on those "standard" parts which the designer and manufacturer of military equipment can specify and include in equipment without special permission.

A digest of the military specifications covering each kind of each component is included, indicating aspects of the component controlled by the specification and those which are not. Tests required for the components to pass inspection, what the tests reveal, and how to make them, are tabulated in extensive tables.

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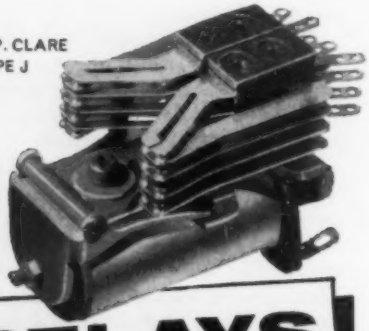

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OUR READERS SAY . . . . . .

Letters should be addressed to the Editor, *Product Engineering*, 330 W. 42 St., New York 36, N. Y.

The Oldest Diesel

To the Editor:

This must be "Remember Old Train Month." Not only did I enjoy your August cover, and "Interesting to Note" item on trains, and the nostalgic comments in Tangents (p. 314) on the Old 1000 Diesel Locomotive, but the Chicago Daily Tribune on Aug. 15 carried a picture of another old diesel. It was No. 1200 of the Gulf Mobile and Ohio Road that pulled the *Abraham Lincoln* between Chicago and St. Louis. I don't know if you have a "Which Paper Do You Read" department, but the Trib claims No. 1200 was the first self-contained diesel. It went into service in 1935 (22 years ago). You claim your diesel is 32 years old. What paper do you read?—Anson E. Meanor, *Chicago, Ill.*

Ed—We were on the right track. The Association of American Railroads tells us that the Jersey Central did have a *switch engine* that went into service 32 years ago. Old 1200 however, was the first diesel *road engine*.

Controversial Shim

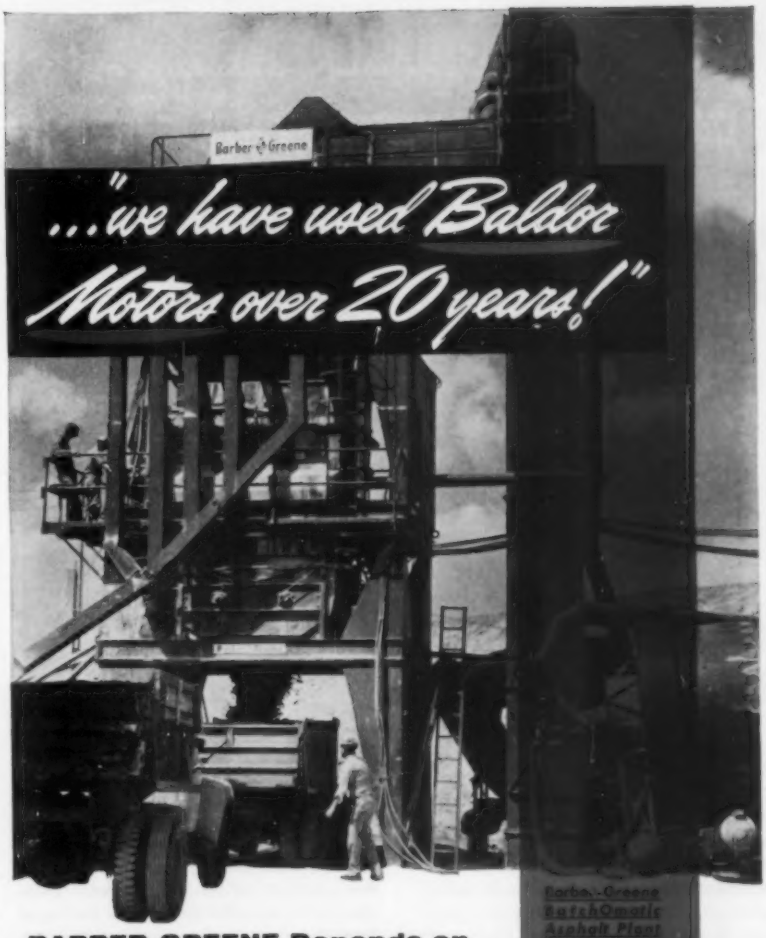
To the Editor:

There are engineers who abhor the very thought of designing with shims. (Aug. '57, p. 164). They raise the counter-question: "What has become of the American achievement of interchangeability?" They say shimming is inapplicable to conveyor lines and incongruous to the automation requirement of sequential assembly.

Shims have been used for emergency mountings on unfinished and noncritical surfaces; on prototypes and special machinery to avoid the expense of tooling. However, they have no place in quantity production for equipment of long service under the guise of compensating for accumulative tolerance.

It would be unfair to criticize the

(Continued on page 197)



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Special Reports On Finishing Non-Ferrous Metals

NUMBER II—Paint Base, Corrosion-Resistant Finishing with Iridite

WHAT IS IRIDITE®?

Briefly, Iridite is the tradename for a specialized line of chromate conversion finishes. They are generally applied by dip, some by brush or spray, at or near room temperature, with automatic equipment or manual finishing facilities. During application, a chemical reaction occurs that produces a thin (.00002" max.) gel-like, complex chromate film of a non-porous nature on the surface of the metal. This film is an integral part of the metal itself, thus cannot flake, chip or peel. No special equipment, exhaust systems or specially trained personnel are required.

Chromate conversion coatings are well known and accepted throughout industry as an economical means of providing corrosion protection, a good paint base and decorative finishes for non-ferrous metals. However, continued developments have been so rapid and widespread that many manufacturers may not be completely aware of the breadth of application of this type of finish. Hence, this digest of current information; to bring you up to date on the many ways in which you can obtain proper surface preparation for painting and increase product durability with a single multi-purpose chemical pretreatment. Report I on decorative, corrosion-resistant finishes and Report III on chemically polished, corrosion-resistant finishes are available on request.

First, it is an accepted fact that metal surfaces should be prepared before painting to make possible an efficient paint system. Naturally, this preparation should provide for good initial paint adhesion. Chemical treatments have proved extremely effective in this respect, particularly those of a neutral or preferably acid nature. Further, to be most efficient, chemical treatments should provide a non-porous barrier to maintain adhesion by sealing the metal from the paint and moisture. They should also provide a self-healing film which prevents lateral corrosion in the event that bare metal is exposed through scratching.

The Iridite chromate conversion coatings meet all these requirements. Iridite is a chemical conversion treatment for surface preparation. It provides initial paint bonding by molecular adhesion. It is acid in nature and produces a film that is gel-like and non-porous in structure. Thus, the Iridite film effectively seals the metal from the paint and from moisture penetration. Because the film contains certain relatively soluble constituents, it will protect areas scratched through to bare metal and prevent lateral corrosion. This is accomplished by a gradual leaching of these constituents into the damaged area.

Further, because of its gel-like, non-crystalline nature, the Iridite film will not affect the appearance or texture of the paint film, nor will it dust or powder to mar the painted surface. Because the film is non-porous, paint coverage is increased, thus substantial savings in paint costs will be realized. In addition, treated parts may be stored for long periods of time prior to painting without the risk of entrapped moisture causing blistering when painting.

Iridite chromate conversion coatings are widely used with equal ease and success under both baked and air-dried paint systems. While the actual adherence properties of the Iridite film do not increase appreciably with its thickness, corrosion protection does. The protection of the Iridite film is proportionate to its thickness and should be taken into consideration when selecting the Iridite to meet your needs. However, it is sometimes necessary to sacrifice maximum corrosion protection for appearance when a finished part is to be only partially painted. For example, it may be desirable to use a thin, clear, bright Iridite film if the unpainted areas must present a chrome-like appearance. A typical case is that of instrument housings on which the exterior is painted and the inside left unpainted.

On the other hand, if all surfaces of the product are to be painted and maximum corrosion protection is required, the heavier and most protective Iridite films should be used. For example, all surfaces of zinc die cast fruit juicers are finished with a highly protective Iridite film prior to painting to provide maximum resistance to the corrosive action of fruit juices.

Iridite finishes are now available for all commercial forms of the more commonly used non-ferrous metals, including zinc, cadmium, aluminum, magnesium, silver, copper, brass and bronze. In addition to providing an excellent base for paint, the Iridite films also have high decorative value when used as final finishes in themselves.

These films can produce a wide variety of pleasing appearances including clear bright, iridescent yellow, bronze, olive drab and brown. In addition, many films can be modified by bleaching or by dyeing. Among the dye colors available are various shades of red, yellow, green, blue or black.

In planning or designing, you should consider the many other characteristics of Iridite finishes which may enter into the specific problem. In addition to their functions as protective and decorative finishes, and as bases for organic finishes and bonding compounds, Iridites have low electrical resistance. Some can be soldered and welded. The film does not affect the dimensional stability of close tolerance parts.

Iridites are widely approved under both Armed Services and industrial specifications because of performance, low cost and savings of materials and equipment.

You can see then, that with the many factors to be considered, selection of the Iridite best suited to your product requires the services of a specialist. That's why Allied maintains a staff of competent Field Engineers—to help you select the Iridite to make your installation most efficient in improving the quality of your product. You'll find your Allied Field Engineer listed under "Plating Supplies" in your classified telephone book. Or, write direct and tell us your problem. Complete literature and data, as well as sample part processing, is available. Allied Research Products, Inc., 4004-06 East Monument Street, Baltimore 5, Maryland.

worm drive in absence of information as to dimensions, production quantity and service conditions. It is evident, however, that for a normal range of size such a worm drive can be designed so as not to require shims, and can be produced interchangeable at a lower total cost, even when allowing for wide tolerance and the resulting cost of gages plus the time devoted to probing for and applying shims.

It is an engineering duty to look beyond such initial selective assembly to the service and maintenance of products of wide distribution. Engineers are interested in design and manufacture without resorting to shims. —GEORGE M. MENCKE, *Wilmette, Ill.*

Author Replies

To the Editor:

My article indicates that shims should be used only: (1) where there is a tolerance pile-up so that, to maintain the final tolerance, each contributing tolerance must be held to an impractical degree; (2) where tolerances can be maintained, but at a cost higher than with shims; and (3) where the product is a custom-built item rather than mass-produced.

Take the worm assembly given as an example; even a rudimentary acquaintance with ball bearings will indicate the great cost of producing only a few units with a width tolerance of much less than the total allowable variation of 0.002 in. This cost would far exceed that of several shimming operations. In fact, bearings are not ordinarily available with a width tolerance of less than 0.002 in.

To throw out, completely and forever, the "abhorrent" shim is a touch of "Front Office Engineering" and avoiding such prejudice is as important to American engineering as the achievement of interchangeability.

In fact, the article is aimed specifically at correcting this avoidance of shims as they can be very effective and economical when properly designed. —THOMAS BARISH

Pulley Problem

To the Editor:

The printing industry widely uses small cotton or rubberized cotton conveyor belts of approximately 1½ in. width and ⅛ in. thickness. Our partic-

(Continued on page 201)

Foldability of Peterson Folda Products Depends Upon Quality Townsend Fasteners

The popular size twin stroller, only stroller with side-by-side seating which will go through standard doorways, being assembled on A. E. Peterson production line.

The extensive line of Folda products produced by A. E. Peterson Manufacturing Company, Glendale, California is designed for baby's safety and comfort—for mother's ease of handling. For instance, she has a choice of ten types and models of strollers.

In designing these unique folding walkers, strollers, chairs, swings, seats and steps, Peterson engineers also had quick, secure, efficient production line assembly in mind. That's why they chose Townsend Company special cold-formed parts, tubular rivets and tapping screws to do the fastening job.

Townsend special parts are used to attach the front wheels, casters and axles. Townsend standard and special tubular rivets are used at all pivot points—the important feature which permits folding for easy storage and handling of their products. Townsend tapping screws are used to attach arm rests and other nonremovable parts.

Peterson officials give credit to dimensionally perfect Townsend parts for the permanent fastening they accomplish which has done much to establish their reputation for quality.

In your assembly operations why not take advantage of Townsend's experience in designing and manufacturing special and standard fasteners for a multitude of uses in all industry. To learn more about how to increase fastening efficiency, write for Bulletin TL-96a to Townsend Company, P.O. Box 237D, New Brighton, Pa.

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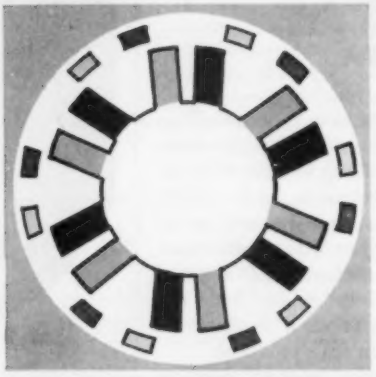

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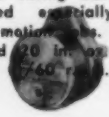

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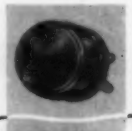

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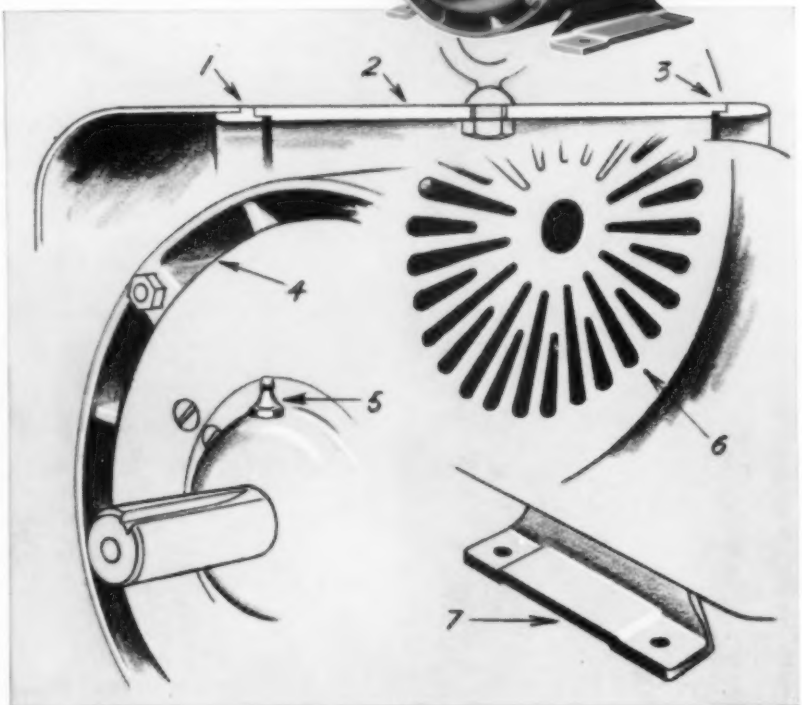
HOWELL MOTOR BRIEFS

Quick facts for those who apply and specify electric motors

Eye Appeal: New Requirement in Motor Design

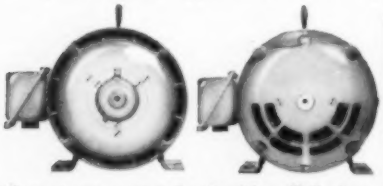
As the trend to automation accelerates and the number of individual drives per machine increases, electric motors become, more than ever, an important element in the overall appearance of many machines. In designing the Howell Series 100 motors in the new frame sizes, Howell engineers set up the list of design requirements shown below. For evidence of how they met them, see the totally enclosed fan cooled motor at right and the detail sketches below it.

When you're specifying motors, why not specify for streamlined appearance—in addition to the top performance you need? It's a bonus value that costs no more and you'll be matching functional efficiency with sleek good looks.



HOWELL SERIES 100 TEFC EXTERIOR DESIGN REQUIREMENTS

1. Fan cover, end-plate and frame to join so as to produce flush exterior surface.
2. No fins, ribs or other protrusions, other than conduit box and feet, around entire diameter of frame.
3. Joint between frame and end-plate to present flush exterior surface.
4. Ventilation ports to carry out contemporary streamlining, offer minimum obstruction to passage of air, and meet or better NEMA specifications for safety.
5. Grease fittings, top-ball type, to be located for (1) easy accessibility (2) maximum protection against damage.
6. Fan guard openings to incorporate distinctive design and to meet or exceed NEMA specifications for safety.
7. Mounting feet to eliminate excess bulk and weight, utilize steel's strength to best advantage. Contours to present good appearance.



Open-type motors in the Howell Series 100 line match their TEFC counterparts not only in streamlined good looks, (see above right), but in diameter and mounting dimensions. Space allocations are simplified.

Series 100 enclosures: totally enclosed fan cooled, open drip-proof, splash-proof and weather protected, and totally enclosed non-ventilated.

Get complete details on these outstanding new motors today . . . write for Bulletin N-100-R

HOWELL Red Band MOTORS

HOWELL MOTORS

HOWELL ELECTRIC MOTORS COMPANY, HOWELL, MICHIGAN

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ular experience deals with #3 thin single belting, of this size. A few years back we changed our pulleys from a straight-taper crown to a nice sweeping 5 in. radius. When we had complaints of tapes running off the pulleys, we increased the guard ridge at the side of the pulley. This, however, did not help. Eventually we went back to the straight-taper crown and all our troubles disappeared at once.

In your article, "How Much Crown Does a Pulley Need," (June '57, p. 185) the author seems to neglect this feature, but with the above tapes it spells the difference between success and failure.

—HELMUTH GUENTHER
Christensen Machine Co.

Author Replies

To the Editor:

I did not say anything about types of crowns in my article because this is still a controversial subject, and there is very little factual data available. In Europe, the radius crown is used almost exclusively, while in America the straight taper crown is generally preferred but usually for manufacturing reasons. However, theory shows that for a given height of crown (difference between radius at middle and at edge) the radius crown is best for high tensions, and the taper crown is best for low tension belts. The reasons are a bit complicated.

Your straight-taper crown pulley, has more total crown than your radius-crown pulley, so your experience is not conclusive in favor of straight taper crown for your application. About a 3½ in. radius would give equal total crowns. Since your belts are probably not working at high tension, I think I would still prefer the straight taper crown for your application.

Flanges are useless regardless of crown, and should be used only when there is the possibility of momentary slippage due to overload, at which time the flanges will keep the belt on the pulleys. They will not correct for misalignment, as you have found out.

It is interesting to hear of this problem, as field experience of this type is often useful.

—WILLIAM A. WILLIAMS

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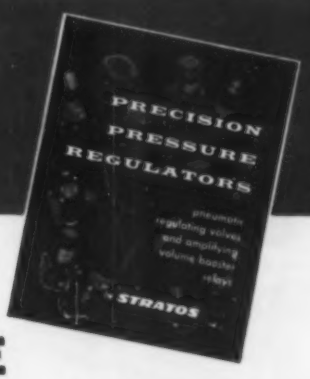

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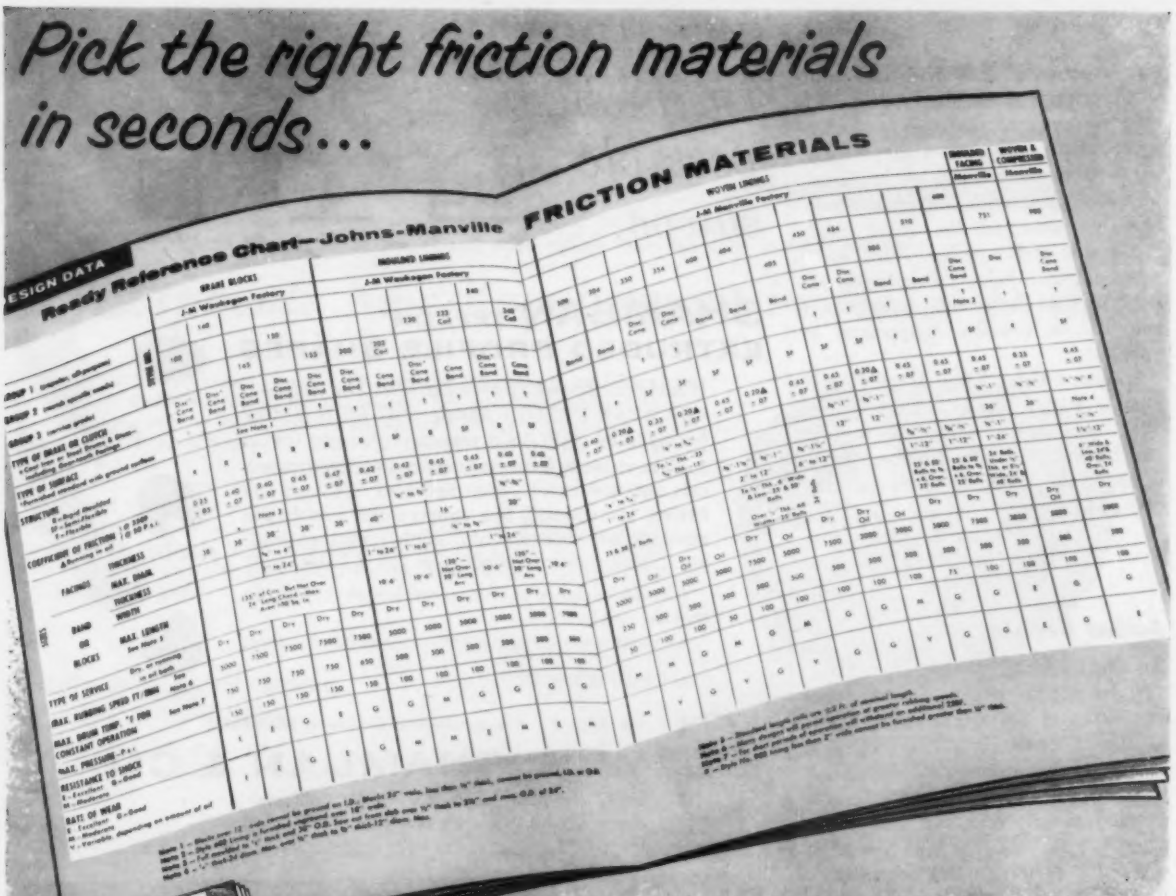

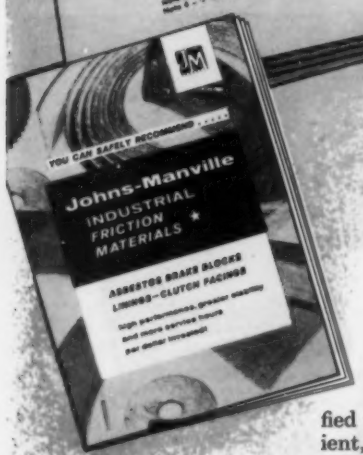

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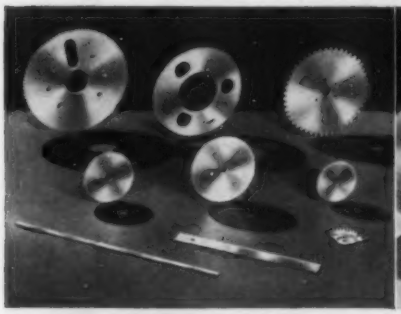

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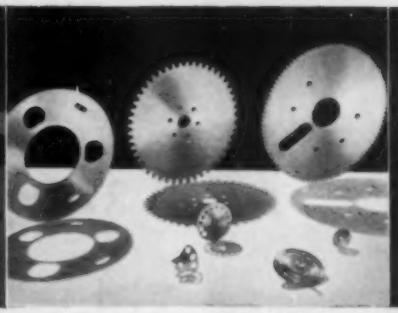

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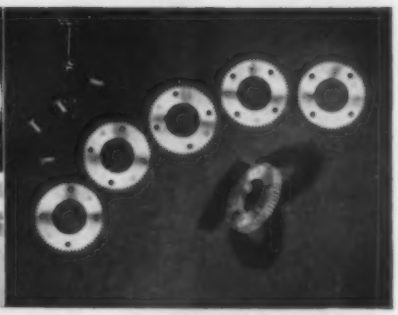

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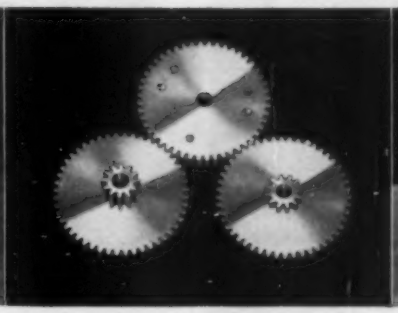

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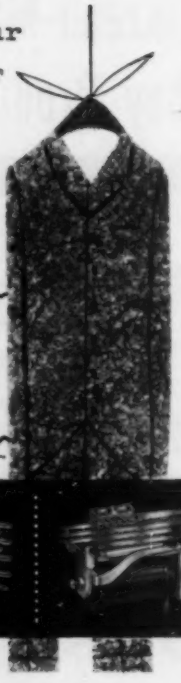

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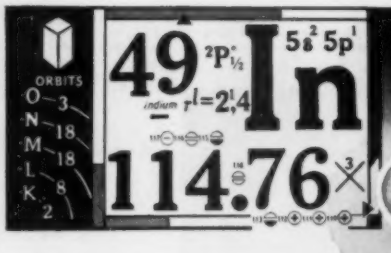

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NEWS

New hydraulic unit pushes pipe with bulls-eye accuracy

On this job, electrical conduit is being pushed under an arterial highway, avoiding expensive trenching. The hydraulic unit, built by Mercury Hydraulics of Denver, can push pipe with amazing accuracy. On a difficult job, this unit pushed 2-inch conduit 186 feet with less than 8 inches deviation from the sighted line!

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Onan engines deliver more horsepower hours per dollar, *step-up performance of power equipment*. **Gasoline models: 1-cyl. 5.5 H.P., 2-cyl. 12.9 H.P., 2-cyl. Diesel, 15 H.P.**

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PRESS PREVIEWS

Lab to Test Electronic Equipment

An environmental test building was opened at the General Precision Lab., Pleasantville, N. Y. The $450,000 structure increases the company's testing facilities for military and commercial electronic equipment by 2½ times. A 23,000 sq ft laboratory houses additional apparatus to simulate extremes of temperature, altitude, humidity, acceleration, vibration and shock.

Lab Will Test Valve Designs

Completion of a new product-development and testing laboratory has been announced by Valvair Corp., Akron, Ohio. Equipped with testing and measuring devices, the lab will be able to determine dynamic characteristics of all type valves and establish the engineering soundness of new designs. Facilities provide for high- or low-pressure air and vacuum tests; air and liquid flow metering; electrical testing, both ac and dc.

Custom-made Transformers

A plant to design and build electronic transformers on a special-order basis has been put into operation in Los Angeles by Westinghouse Electric Corp. The program calls for a staff of design engineers working with sales engineers to meet needs for special transformers. The facility is equipped to manufacture small quantities of samples and prototypes. When these are needed in large quantity, they will be manufactured at the company's main specialty-transformer plant, Greenville, Penn.

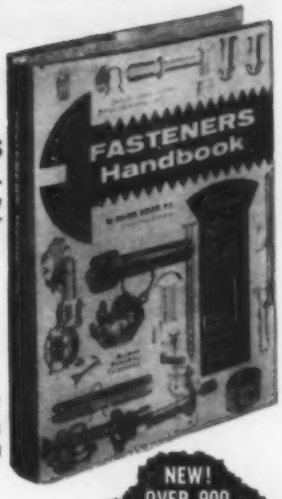
Company Seeks New Silicone Rubber Techniques

Dow Corning Corp., Midland, Mich., has opened a quarter-million-dollar Silastic Experimental Fabrication Laboratory. Its 11-man staff will be primarily interested in develop-

(Continued on page 209)

Details, ideas, sources for all fastening needs . . .

FASTENERS Handbook



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- Brings to your attention the many cost-saving features of available, less-known fasteners.
- Presents complete fastener lines in particular fields and applications. Enables you to look at what's available before closing up.
- Makes possible the immediate location of every fastener described with name and address of supply source.
- Relates actual uses of fasteners in one industry to those of another, resulting in concrete examples of money-saving applications.

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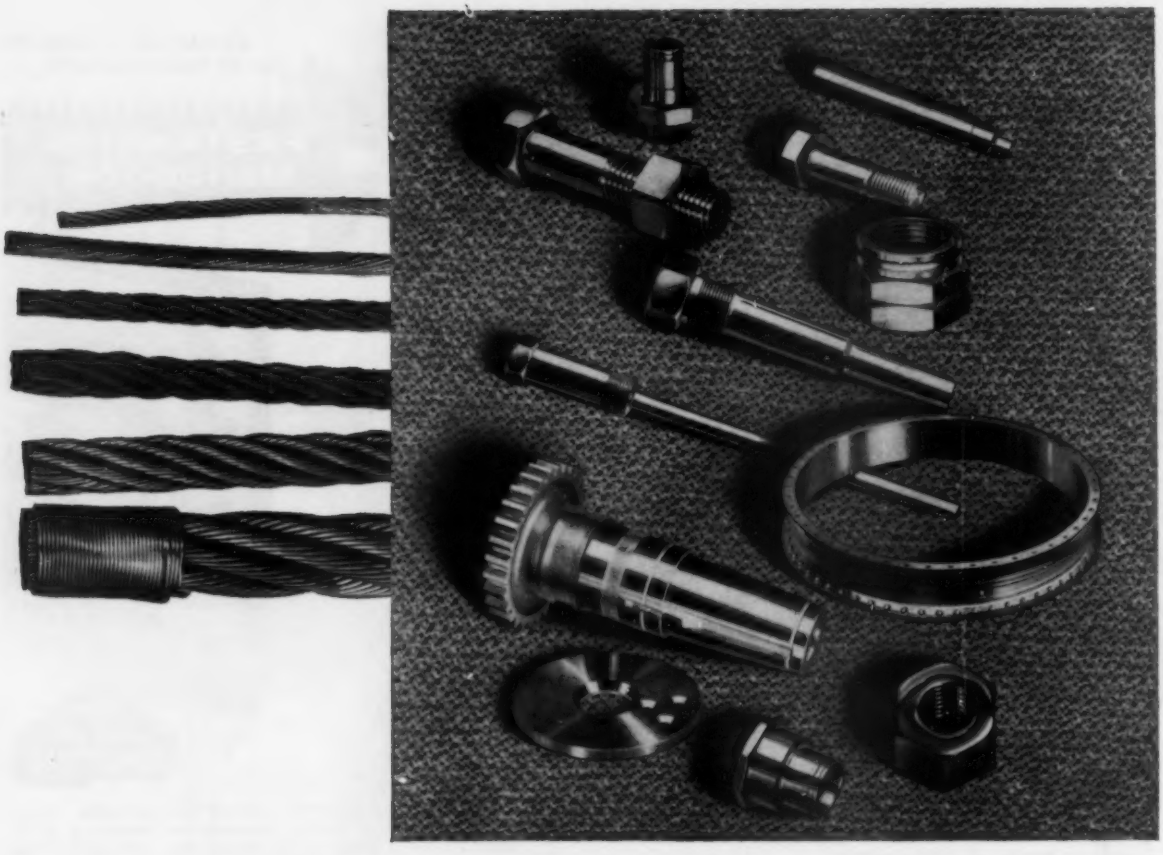

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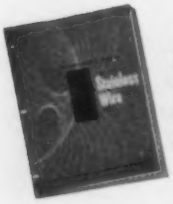

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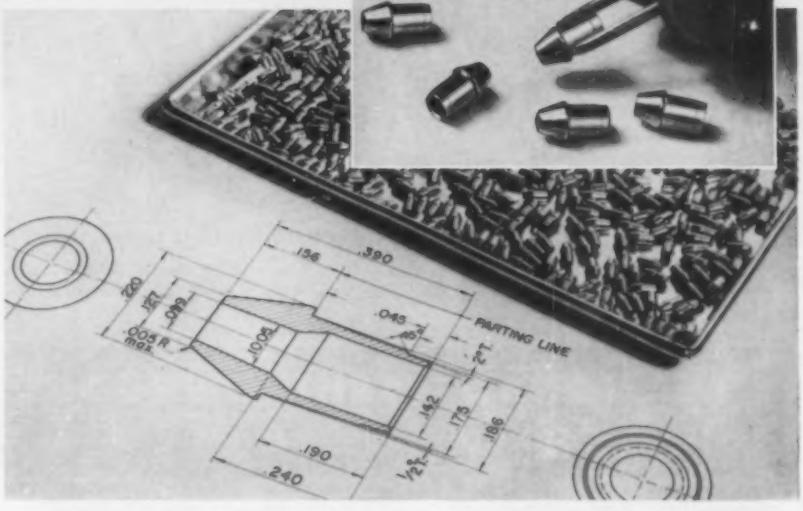
GRC DIE CASTING TECHNIQUES CUT COST ON TINY BUSHING TO $2.00/M

Simple part less than ½" long mass produced in zinc alloy in a single automatic operation



This tiny bushing is used in a ball point pen. Overall it is .390" long and .220" wide. It was formerly made on screw machines, but Gries Reproducer Corporation was able to die cast it in zinc alloy in a single automatic operation reducing the cost to little more than $2.00 per thousand. In addition to lowering costs substantially, GRC exclusive methods guaranteed the perfect uniformity of each individual piece in the million part run. The manufacturer also took advantage of GRC's service to their customers on secondary operations and had the part nickel plated.

Not only in this case, but in many others in which both commonplace and extremely intricate parts were involved, Gries unique patented die casting techniques have made possible exceptional savings and broad flexibility in design.

A fact-filled die casting bulletin, yours for the asking, is put out by GRC explaining their exclusive methods and showing how Gries has helped solve problems on parts "no bigger than your thumbnail" (maximum is 1¾" long, ½" oz., no minimum).

Special Design Wing Nuts to Meet Unusual Needs Now Stocked by GRC

GRC lists in a recently issued catalog sheet the complete specifications on their wide assortment of special design Wing Nuts—High Wing, Round Wing, Low Wing, Low Low Wing and Special Low Wing styles—in a wide range of blank and thread sizes. Also cataloged are Senior, Junior and Economy Type Wing Nuts with plain or serrated bases. In all, more than 100 separate types are listed.

Fastenings are die cast in zinc alloy in quantity to assure uniformity and keep prices low thru GRC's unique techniques.

This new catalog sheet and catalog sheets on their round head thumb and cap nuts, wing and round head thumb screws, rivets, etc., available direct from Gries Reproducer Corp.

Small Gears, Pinions, Hubs, Shafts, etc., Available Individually and in Various Combinations from Stock Dies

GRC issues a catalog sheet listing more than 40 individual items and stock sizes of gears, pinions, hubs, shafts, etc., available individually and in various combinations. All items listed are automatically die cast of zinc alloy . . . all combinations are made in one piece. Holes, shafts, spacers, shoulders, etc., are to order and no extra tool charge is made on quantities.

Gries Reproducer Corp. will also die cast in zinc alloy on special order unusual shapes, meet extra precise requirements, in quantities from 50,000 to millions. Prompt quotations on special orders will be made upon receipt of blueprints or specifications. Stock catalog sheet will be sent on request.

Helpful New GRC Kit is Big Aid to Product Designers

Gries Reproducer Corp. has developed a new kit for designers and production men. Its purpose is to acquaint them with the almost unlimited scope in small parts design and the tremendous savings which GRC exclusive methods make possible.

The kit concentrates in one unit informative data on the extent and flexibility of these unique processes; including one-piece zinc alloy die castings, "Intercast" movable, multiple element units, nylon and other plastic moldings, standard components: fastenings (wing and round-head thumb nuts and screws, cap nuts, rivets, etc.), gears and pinions, toy parts, miniature novelties, nylon screws and coil bobbins.

You can obtain this new GRC Product Designer's Kit by writing direct to Gries Reproducer Corp.

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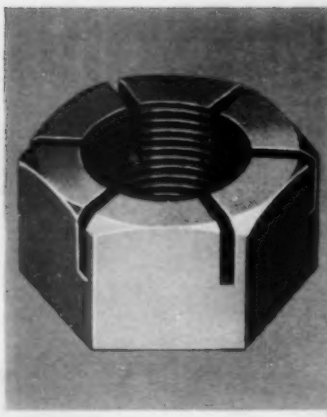
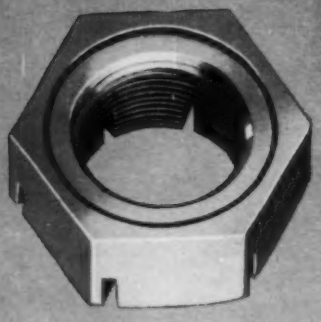
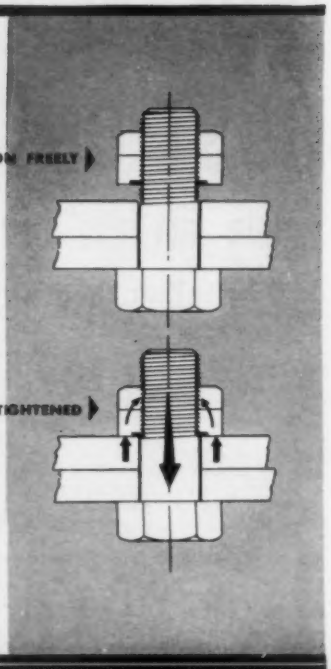


the
MARSDEN
free running lock nut





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ing fabrication techniques for silicone rubber. The lab is also responsible for evaluating new Silastic stocks, improving current fabrication methods, training new sales and engineering personnel, and training people in production techniques.

Honeywell Enters Plastics

Minneapolis-Honeywell Regulator Co. is now in the field of plastics with full-scale production of epoxy casting and potting compounds designed especially for needs of the electronics industry. The new operations are centered in the company's main plant at Minneapolis.

Honeywell has developed an epoxy hardener for use where severe and unusual environmental conditions are a problem. Special features of the company's epoxy compounds include low thermal coefficient of expansion and good electrical insulation properties, along with a flexural strength of 14,000 psi.

Continuous Operation in Vacuum Metallurgy

A vacuum metallurgy unit designed for continuous operation is part of the technical development program established at the Muskegon plant of Misco Precision Casting Co., Whitehall, Mich.

It is one of the changes that is expected to be important in company

(Continued on page 395)

"Frankly—I never do my best the first time or you'd have no improvements to suggest."

NEW
from
MEYERCORD

NAMEPLATE DECALS

If you have adhesive problems with the water applied decals you are now using...switch to NEW MEYERCORD TYPE I

This is BIG NEWS about a new addition to the Meyercord "family" of commercial nameplate decals! Meyercord has perfected a completely new water applied decal nameplate with revolutionary advantages.

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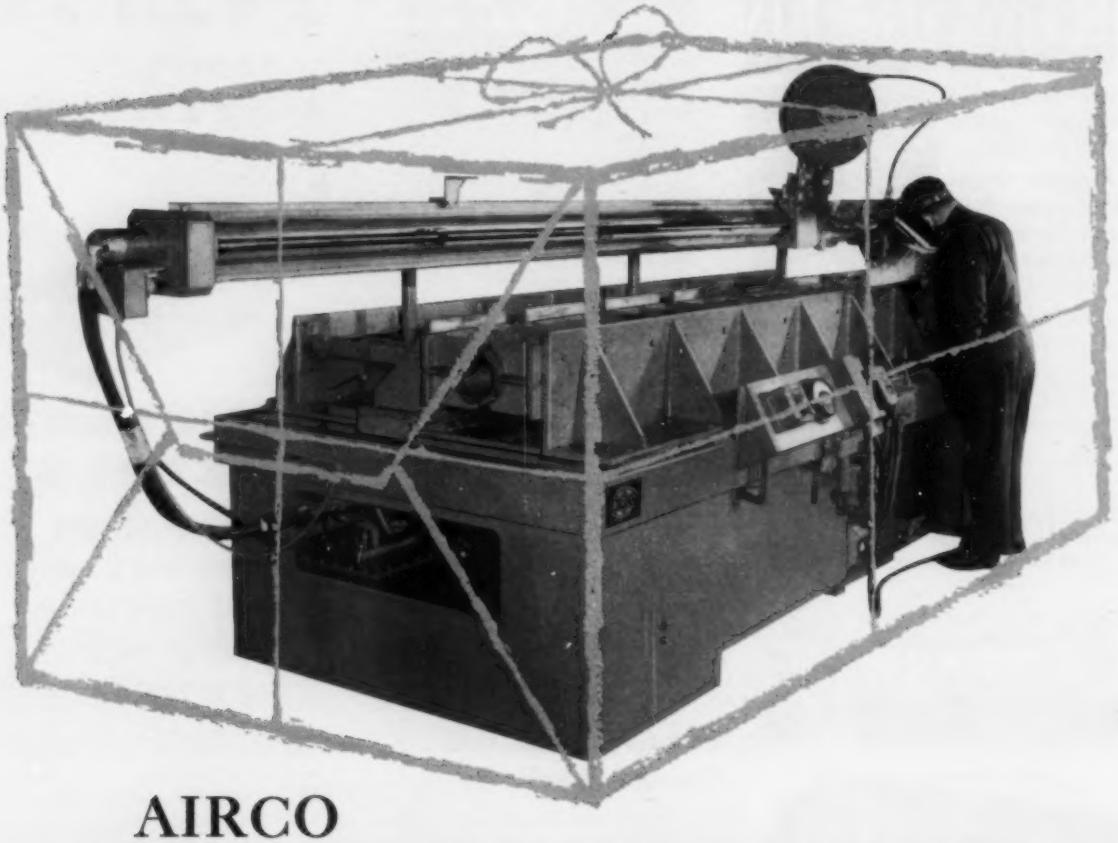

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Airco's Machine Welding Department can relieve you of many of the problems involved in installing an automatic welding operation in your plant. This welding-and-engineering service custom engineers automatic welding operations to your product design. Airco designs, constructs and installs all welding machine tools. Airco selects the most suitable welding equipment for the job, supervises installation, works out "bugs," and trains your employees in the operation of the equipment. You get a completely engineered "package."

Airco accepts full responsibility until the system is operating to your complete satisfaction. Airco's Machine Welding Department has already completed over 36 projects covering a wide range of automatic welding operations. For more information, write to J. H. Berryman, Machine Welding Department, at the address below.

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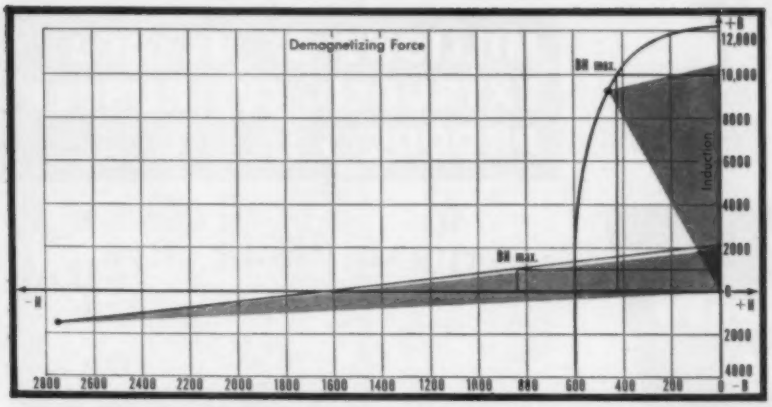

Composite of demagnetization curves showing that for Alnico V, upper, and Indox I, lower. Operation in the third quadrant is produced when a demagnetizing force, stronger than the magnet, forces flux in a direction opposite normal operation, providing negative magnetic induction. Indox magnetic flux returns to full value when this force is removed.

Why Ceramic Magnet Fields Are Now Practical for D.C. Motors

G. R. Hennig, Senior Design Engineer, The Indiana Steel Products Company, explains in this interview why Indox ceramic magnets are now practical for d.c. motors ranging from fractional to multiple horsepower.

Question: Why is the use of Alnico magnets limited to rather small motors, such as toy motors? Why are only some very special larger motors equipped with permanent magnet stators at the present time?

Answer: The price per unit of usable magnetic energy dictates the size limit. Alnico contains very expensive raw materials. For small magnets weighing a fraction of an ounce, this is not too significant. Labor cost, however, the other main factor in any calculation, is a sizeable item in small units. This is not true when larger Alnico magnets are required. With Indox the opposite is true. Its raw materials are cheaper than copper, and it appears that the larger the motor—within a certain limit—the more economically the material can be applied.

Question: How can Indox I, with only ⅕ the energy product (BH max), of Alnico V, be recommended for motor usage where a high field energy is required?

Answer: Maximum energy product is a good criterion of quality for static conditions, such as in the magnet systems of moving-coil instruments or loudspeakers. In motors, generators, and many other applications where the magnet is subject to strong demagnetizing forces, maximum energy product is not an important consideration. One must consider the incremental permeability, even in the third quadrant of the hysteresis loop. The result is, that under the most extreme conditions, Indox I has a maximum usable energy of 17.4 in.-lb. per pound while Alnico V has only 13.7 in.-lb. per pound. Under conditions as found in motors, the usable energy of Indox I is about ½ instead of ⅕ of the usable energy of Alnico V.

Question: How does Indox V compare with Indox I and Alnico V, and where does this material find application?

Answer: Indox V is the strongest ceramic magnet material available today. Per unit of volume it provides more usable energy in motors than Alnico V does. Flat pieces with at least 2 sq. in. area are preferable for production. This means that Indox V is suitable for motors with about 1/25 hp and more, and not for the tiny toy motors.

Question: What are the size limitations for Indox I and Indox V motors?

Answer: Indox I is suitable for motors from the smallest possible size to about ⅛ hp. Indox V can be applied in much larger motors, possibly in the range up to 10 hp, or higher. The same applies for generators.

Question: Can any d.c. motor be converted to a permanent magnet-field motor?

Answer: Yes, most motors can be converted with very little design change. Others may require a considerable change in structure and layout of the armature.

Question: Is there a problem of meeting air gap tolerances with Indox I ring or segment stators, unless bore grinding is applied?

Answer: No. Even though there is an as-sintered tolerance of ± 1.5%, an Indox magnet may be compared with an air-core solenoid, and variations of the air gap length have little influence on the usable flux. Only the O.D. should be ground which is an inexpensive operation on centerless grinders.

Question: How will a permanent magnet motor compare with shunt or series wound motors?

Answer: In general, a permanent magnet motor will have characteristics falling between shunt and series wound motors. Although it will not duplicate the entire speed torque curve for either, it can duplicate characteristics over a specified range.

Question: What are the specific advantages of substituting permanent magnets for wound fields in motors?

Answer: The advantages are: Higher efficiency, cooler operation, less use of critical material such as copper and, possibly, simplification and cost reduction.

Question: Is there a possibility of using Indox in a.c. motors?

Answer: Yes. In addition to various synchronous timer motors, d.c. motors with Indox magnets can be used with the new, efficient power-rectifiers (silicon or others). The advantages over normal d.c. motors are higher starting torque and better speed regulation.

Question: How is the speed controlled in permanent magnet motors?

Answer: Normally, by varying the armature voltage, but also by using a magnetic shunt, by moving the armature axially out of the permanent magnet field, by rotating the brushes, or by an auxiliary field winding.

Question: Can a permanent magnet stator compete with an equal electromagnetic stator in size or total volume?

Answer: Yes, with the materials we have today it can. There is only one exception: Where wound fields are operated with high, short-time overloads.

A complete reprint of Mr. Hennig's paper, "Applying Ceramic Permanent Magnets to Motor Design" appears in the July-September *Applied Magnetics*. Write today for your copy. Dept. C-9.

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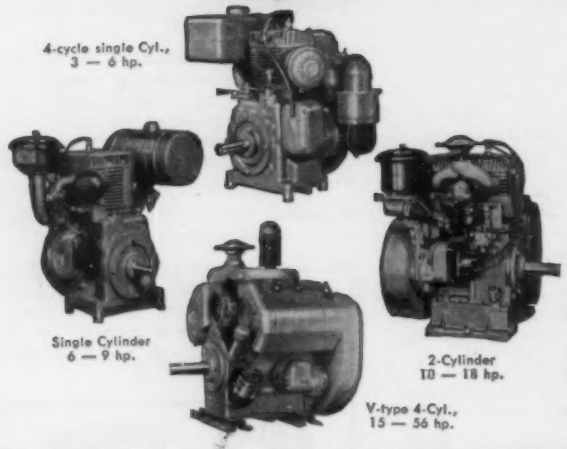

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2. All Wisconsin Engines are of heavy-duty design and construction in all details... built for long life and low-cost maintenance.
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In addition, you have the most complete line in the industry from which to choose . . . 3 to 56 hp., in 4-cycle single cylinder, 2- and 4-cylinder models . . . backed by Authorized Service Stations and Distributors throughout leading world markets.

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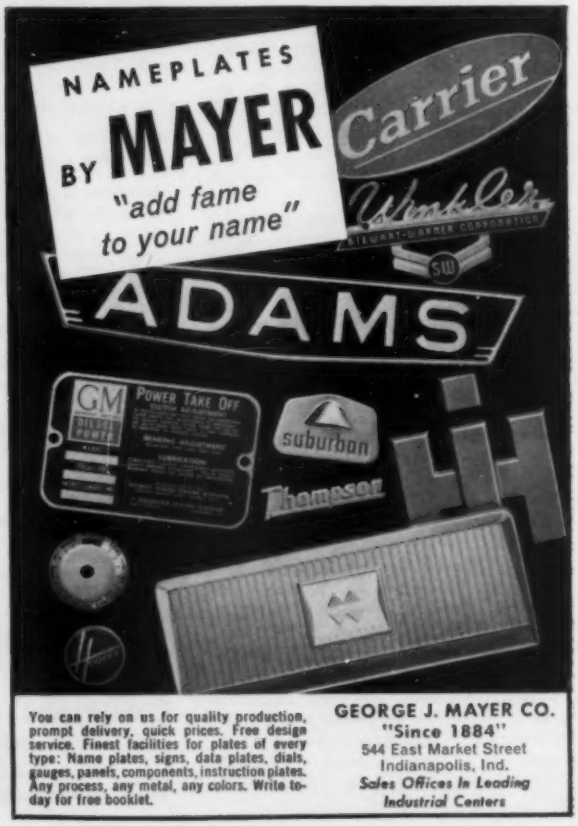

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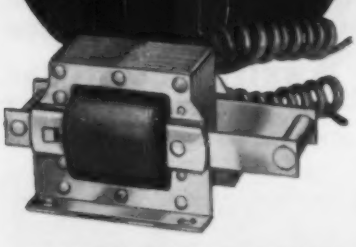

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growth. Hot molds can be charged as required through a system of vacuum interlocks so that constant vacuum is maintained in the melting chamber.

For large castings, a method has been inaugurated that does not require a vacuum. It makes a cope, drag and core section of the mold from ceramic investment material. A quick-setting high-temperature ceramic cement bonds the refractory materials as they are cast against the metal pattern or match-plate. The mold sections are oven-dried, then assembled as a complete mold. This is preheated to the desired temperature (1500 to 1700 F) then withdrawn from the preheat furnace for the pouring operation. The process is adaptable to molds that take up to 150 lb of metal. Stainless-steel alloys and low-alloy steel can be cast with this new process effectively.

Zirconium Melting Plant

Reactive Metals' zirconium melting plant in Ashtabula, Ohio, beginning production this month and rated as the nation's largest, will produce ingots and a complete line of mill products from zirconium, also hafnium and other reactive metals.

The plant will have 23,000 sq ft of shop area, plus office and laboratory space, and an employee facility section. Initially the plant will employ about 85 people. Equipment will include large double-melting consumable electrode furnaces to make the zirconium ingots. A 3,000-ton hydraulic press is also being installed. It will make the compacts for consumable electrodes from zirconium platelets supplied by the neighboring U.S.I. sponge plant.

Polymers Added to Research Program

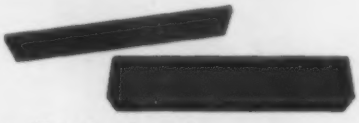
A two-story polymer laboratory costing over $500,000 will be built by Air Reduction Co., Inc., to house additional chemical research facilities at Murray Hill, N. J. It's scheduled for completion by the end of this year and will be devoted to developing polymers primarily for paints, adhesives, plastics and coatings. It will add about 35 persons to Air Reduction's staff.

The company's diversified research

(Continued on page 215)

SEEKING THE IDEAL MATERIAL FOR...

• **Molds for powder metallurgy?**



• **Sintering boats?**

• **Crucibles, jigs, plates?**

• **Similar hot applications?**

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Speer carbon and graphite parts are not wetted by molten metals. They hold their shape with no warping, regardless of temperature. They have high heat transfer and will not break down under severe thermal shocks...will not crack or split... are chemically inert.

Easily machined or fabricated, Speer carbon and graphite parts can be provided in almost any size and shape to your *exact* dimensional tolerances. If you have a design problem involving high temperatures, examine the advantages—and economies of Speer Carbon. Speer's knowledge and experience is yours for the asking—mail the coupon today for further details.

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Some SANDSTEEL Pointers On Selecting SPRINGS

For Your Product

Here are the two basic types of Sandsteel springs along with a general indication of the type of service they are suited for.

SPIRAL
For Ordinary Applications

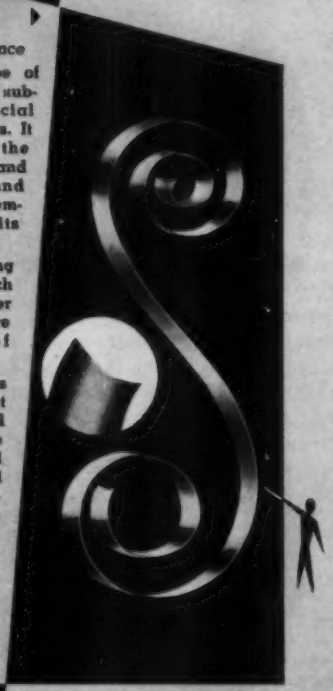
This is the common clock spring or hairspring, which can be operated within a spring drum or anchored to a post so that it will function without support around its circumference. This is the type of spring used in recoil starters for gasoline engines, guard return springs for portable electric saws, wind-up springs for toys or tension devices where constant torque is not critical.

SANDSTEEL CROSSCURVED
For Super-Performance

In this unique type of spring, the steel is subjected to our special crosscurving process. It is curved across the width of the strip and the spring is wound against both its tempered spiral and its convex curvature.

This gives the spring a dual tension—which provides dual power and a longer, more even release of energy.

This type of spring is used where constant power is required through one or more revolutions. Typical applications would be for timing instruments, carriage return springs for typewriters and office machines, power springs for motion picture cameras and other applications requiring precision power springs.



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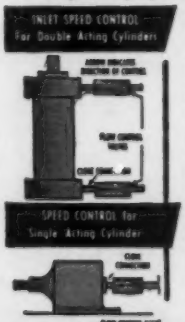

Pneu-Trol Speed Control Valves, are widely used in hundreds of control applications because they combine in a short, compact body, a tapered fine thread needle for extremely accurate air or oil flow control and a floating retro ball check, which permits full flow in the opposite direction. Retro ball floats in most sensitive position to its seat, requiring only a slight differential pressure to fully open or close it.

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program in the fields of chemistry, metallurgy and cryogenics has a double purpose: developing new products and processes; finding new uses for existing products.

Steelmaker Adds Sintering Plant

A sintering plant designed to expand Inland Steel Company's ironmaking capacity by 300,000 tons a year is under contract at the Indian Harbor Works. The new plant, which will treat fine ore before it is fed into the blast furnace, will have twice the capacity of the present sintering facilities.

The plant will supply material to six of the company's eight blast furnaces, and is part of its $280 million three-year expansion program. Now at approximately half-way point, the plan will lift its steelmaking capacity 15 percent by the end of 1958.

Magnetic Amplifier Laboratory

To facilitate the research and development of magnetic amplifier products, American Electronics, Inc., has estabilshed a new magnetic amplifier laboratory at its Electircal Machinery and Equipment Div., in El Monte, Calif.

The laboratory is concentrating mainly on the development and prototype manufacturing of static d-c power supplies, a-c line regulators, static inverters and converters, static frequency multipliers and magnetic servo amplifiers.

New Building For Techalloy Co.

A $65,000 expansion program will soon result in initial production from a new 24,000 sq ft one-story building at Techalloy Co., Inc., Rahns, Pa. Full production will begin in December of this year and it is estimated that current shipments will be doubled in 1957 and tripled by 1958.

Building contains equipment for fine-size drawing of Monel, nickel, Inconel, stainless and heat resisting steels. For full production, additional

(Continued on page 217)

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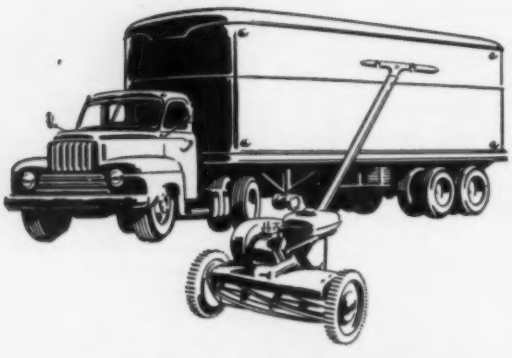

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Add up all the advertisers and you've got a gold mine of current, on-the-job information. Yours for the reading are a wealth of data and facts on the very latest in products, services, tools . . . product developments, materials, processes, methods.

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McGRAW-HILL PUBLICATIONS

equipment will consist of new slitting machines, modern four-high reversing mill for strip up to 8½ in. wide and a hydrogen strand annealing furnaces.

Aviation Systems Development Laboratory

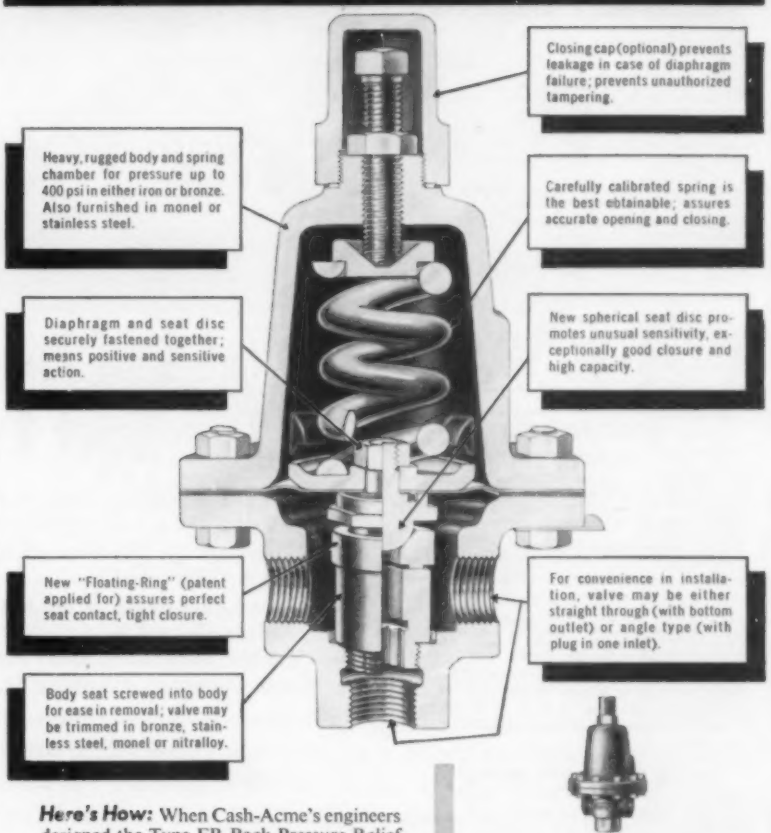
A new development laboratory for testing aircraft electrical systems has been established by the General Electric Co at Waynesboro, Va. The facility enables engineers to determine complete system operation including the simulation of feeder impedances of aircraft. Responsibilities of the laboratory include: development and evaluation of systems under contract; development and evaluation of new systems for future aircraft; system testing for qualification and development; and training, demonstrations and customer service.

Electrical Components Plant

Construction has begun on a branch manufacturing plant at Lafayette, Ind. by the Rea Magnet Wire Co., Inc., Fort Wayne, Ind. The company produces electrical conductors for motors, transformers, coils and other electrical components. The building will have 100,000 sq. ft. of floor space, including offices and service areas. The plant will employ approximately 100 personnel.

"They have such a sweet way here of persuading draftsmen to work nights."

how Cash-Acme provides the Correct Answer to high back pressure valve maintenance costs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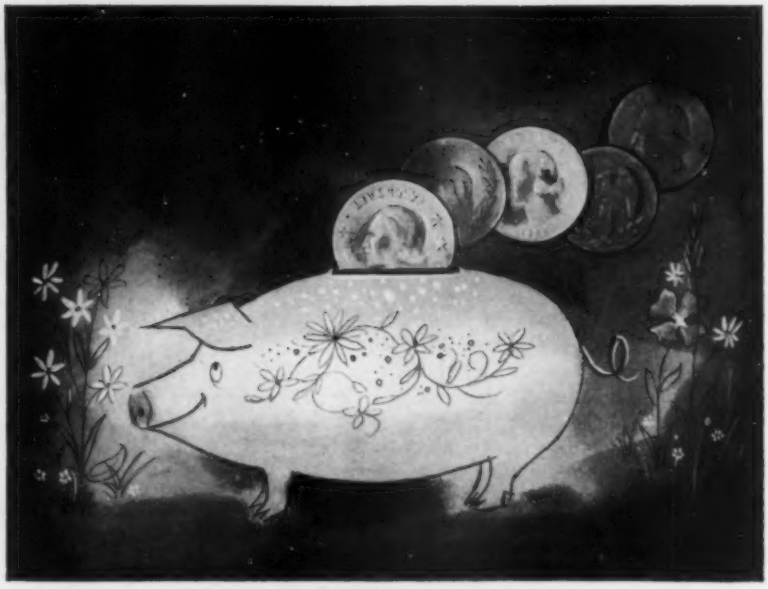

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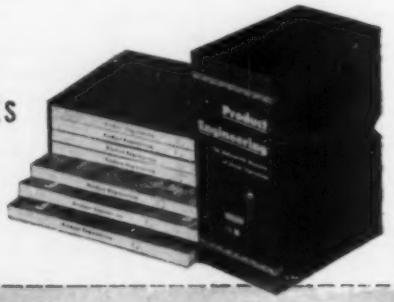

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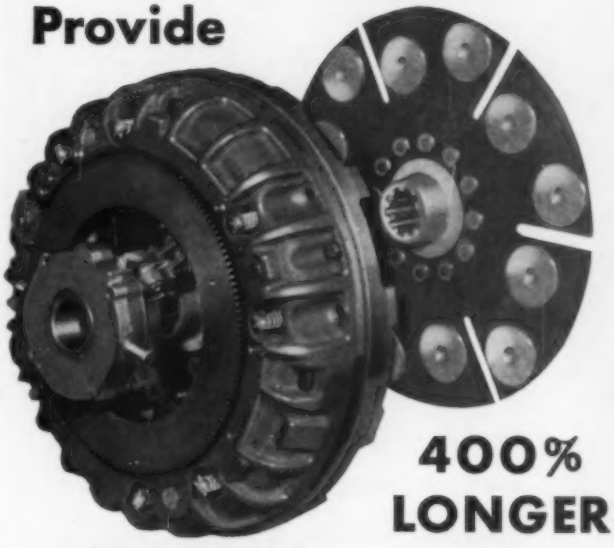

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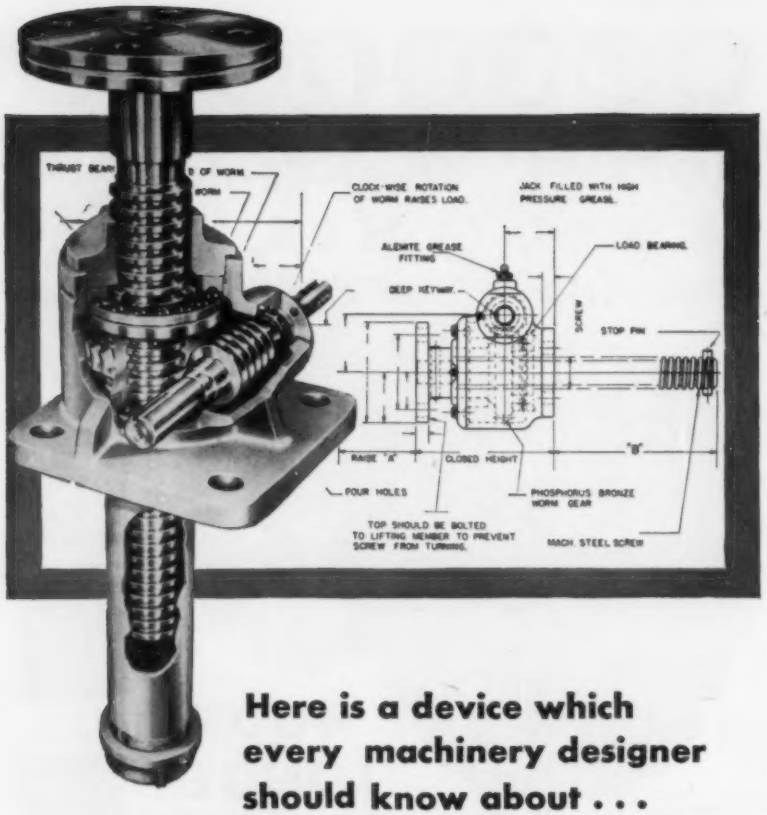

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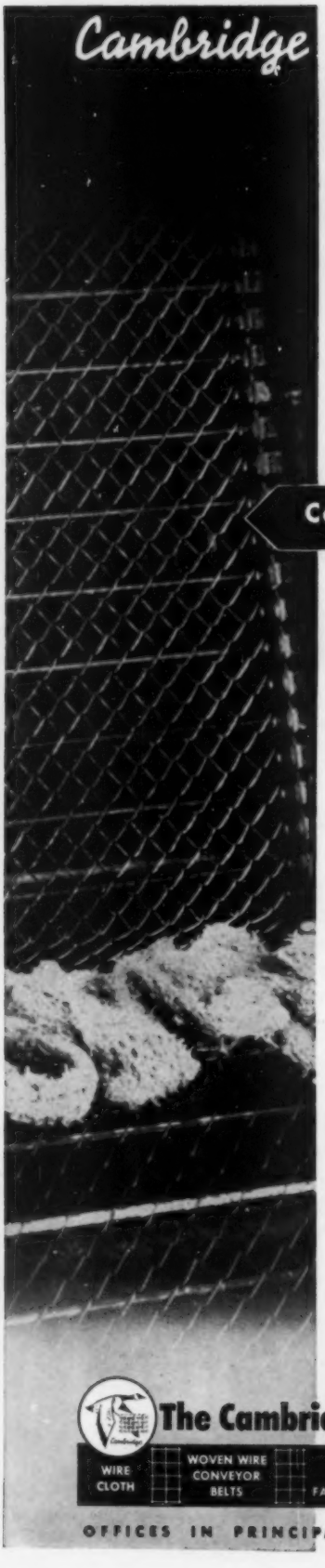

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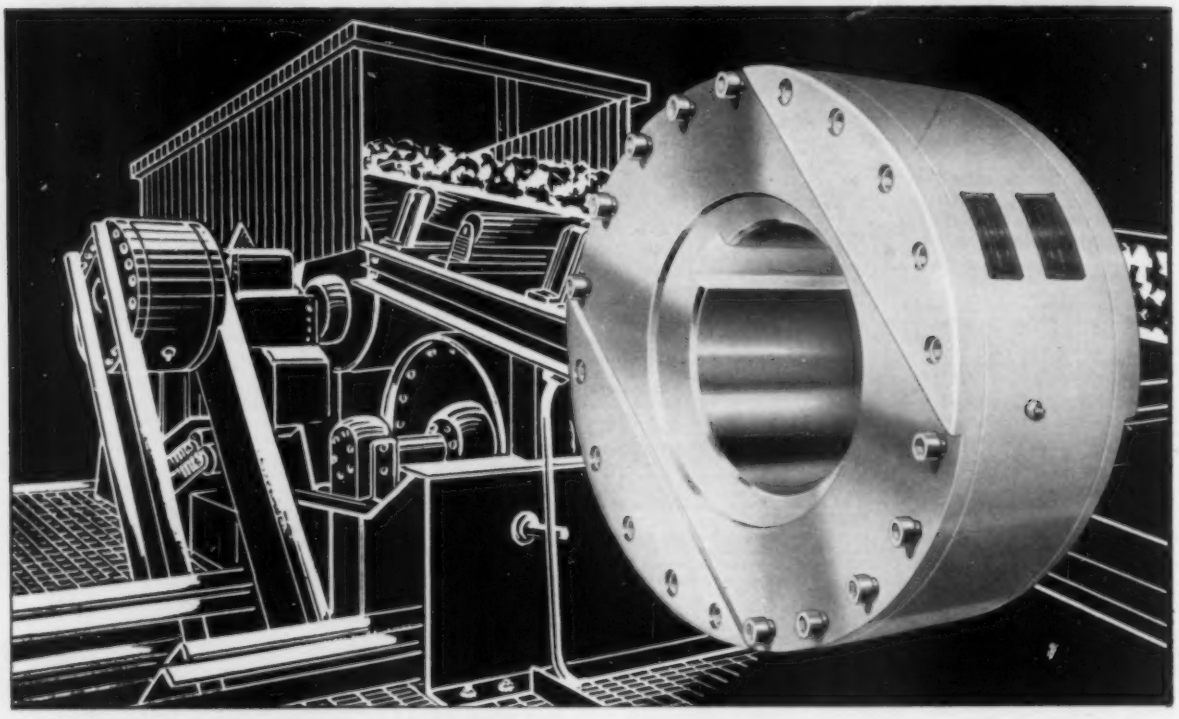
136,500 Ft.-Lbs. of Holdback Torque



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FS-1150	170	24000	450
FS-1200	140	36000	650
FS-1250	130	51500	1000
FS-1300	115	73000	1250
FS-1400	100	136500	2200

Over-Running, Indexing and Backstopping Clutches for aircraft, automotive and various industrial applications

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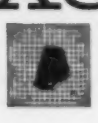

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For your copy of any new catalog or bulletin, circle key numbers in the space indicated. Bulletins are described on pages 169-177.

To get more data about new Components, Materials and Parts fully described on pages 127-167, just circle the appropriate key number.

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Description of these new engineering materials appear on pages 127-167. Circle key number for more data

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3—Low-pressure Control Switch
4—Wrist-watch-sized ¼ hp Pump
5—Combination Cam-Interval Timer
6—Self-locking Threaded Insert
7—Custom Meters
8—Clutch With Stationary Magnet
9—Miniature Photoelectric Projector
10—Flexible Printed Cable
11—Pressure Transducer of 1 Cu. In.
12—Condenser
13—Indicating Switch
14—Four-digit Stroke Counter
15—Ceramic Relay
16—Modular Design Potentiometers
17—Size, Position Indicator
18—Gear Motors, 1 to 10 hp
19—Mercury Switch
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21—Four-position Control Valve
22—Directional Control Valves
23—Transistor Clip
24—Breakout for Multiconductor Cable
25—Matched Bellows
26—Flame-retardant Epoxy Laminate
27—Pressure-sensitive Teflon Tape
28—Cost Aluminum Flexible Coupling
29—Enclosed Plug-in Relays
30—Beam Compass
31—Miniature Self-locking Clinch Nuts
32—High Output Pressure Transducer
33—Laminated Transmission Belt
34—Waterproof, Vibration-dampening Fastener Seal
35—Spring-loaded Check Valves
36—Sealed Gear Pump for Lubricating
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39—Tracing Paper and Cloth
40—Portable Power Supply
41—Disposable Molds

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listed below are described on pages 169-177. Circle key number for your copy.

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45—Self-locking Hex Head Cap Screws, 4 pp., Cleveland Cap Screw Co.
46—Sealing Compounds, 4 pp., Presstite-Keystone Engineering Products Co.
47—Tubing for Cylindrical Parts, 4 pp., Tube Reducing Corp.
48—Bronze and Iron Body Valves, 136 pp., Fairbanks Co.
49—Plastic Sheets, Rods, Tubes, 76 pp., Allied Plastics Supply Corp.
50—Cold Finished Steel Bars, Wall Chart, La Salle Steel Co.
51—High-temperature Alloy, 24 pp., Haynes Stellite Co.
52—Environmental Testing, 4 pp., Associated Testing Laboratories, Inc.
53—Rubber Parts, 12 pp., Williams-Bowman Rubber Co.
54—Limit Controllers, 4 pp., Daytronic Corp.
55—Electronic Equipment, 5 Sheets, Electronics Div., Posi Machinery Co.
56—Manual Motor Starters, 8 pp., General Electric Co.
57—Stainless Steel Sand Castings, 4 pp., Alloy Steel Casting Co.
58—Steel Hubs, Malleable Split Taper Bushings, 4 pp., Browning Mfg. Co.
59—Ceramic Magnets, 12 pp., Stackpole Carbon Co.
60—Federal Engineering Careers, 12 pp., U. S. Civil Service Commission
61—Roller Chains and Sprockets, 68 pp., Diamond Chain Co., Inc.
62—Titanium, 24 pp., Mallory Sharon Titanium Corp.
63—Metal Holdings, 68 pp., John Lees Div., Serrick Corp.
64—Miniaturization of Self-locking Nuts, 36 pp., Elastic Stop Nut Corp.
65—Alloy Steel and Iron Castings, 24 pp., Howard Foundry Co.
66—Expanding Blind Rivet, 8 pp., Star Expansion Industries
67—Rapid Reversing Motor, 4 pp., General Electric Co.
68—Magnesium, 24 pp., Howard Foundry Co.
69—Aluminum and Brass Castings, 24 pp., Howard Foundry Co.
70—Cellular Rubber, 28 pp., B. F. Goodrich Sponge Products
71—How to Eliminate Cracking Hazards, 8 pp., Carpenter Steel Co.
72—Self-locking Bolts, 4 pp., Republic Steel Adv. Div.
73—Pneumatic Control, 44 pp., Bristol Co.
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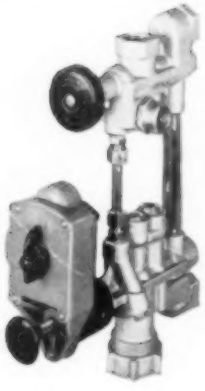

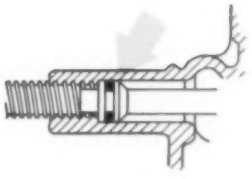

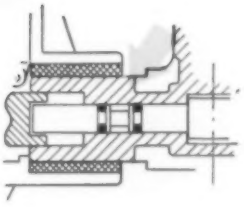

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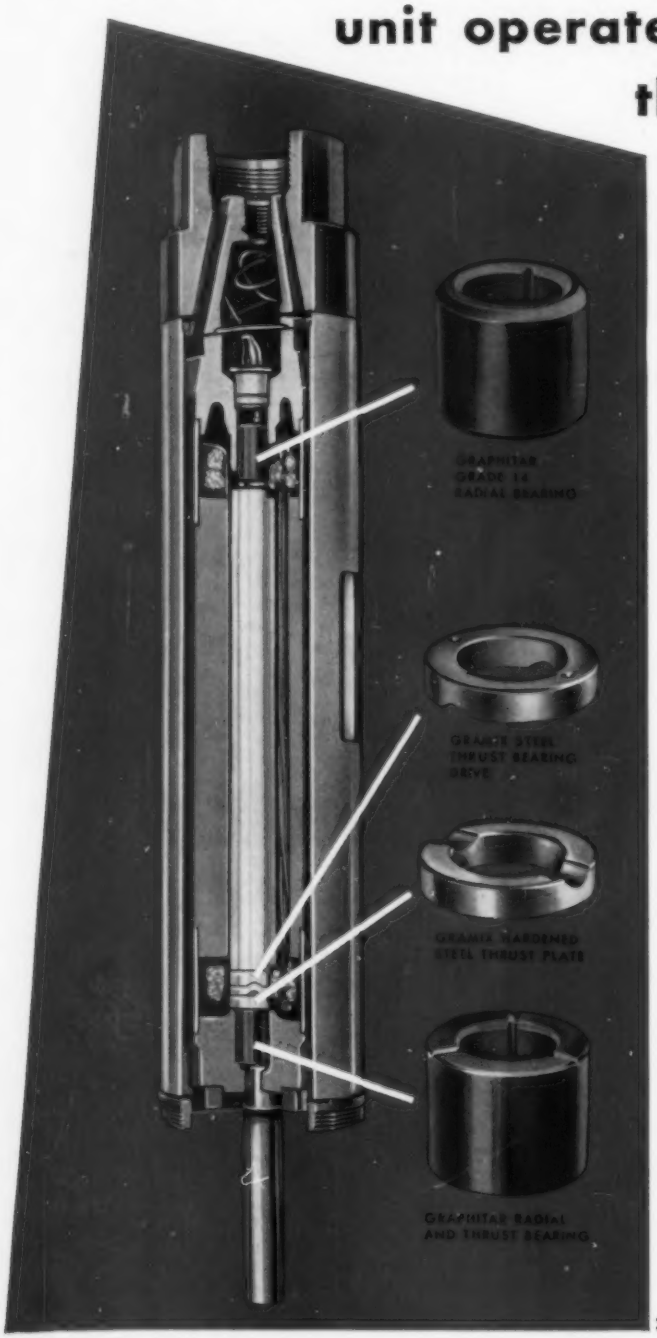
bearings in Leland submersible motor unit operate with gasoline as the only lubricant


GRAPHITAR GRADE 14 RADIAL BEARING
GRADE STEEL THRUST BEARING DRIVE
GRAMIX HARDENED STEEL THRUST PLATE
GRAPHITAR RADIAL AND THRUST BEARING

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